TECHNOLOGY DEPT

February 1941

TECHNOLOGY REVIEW

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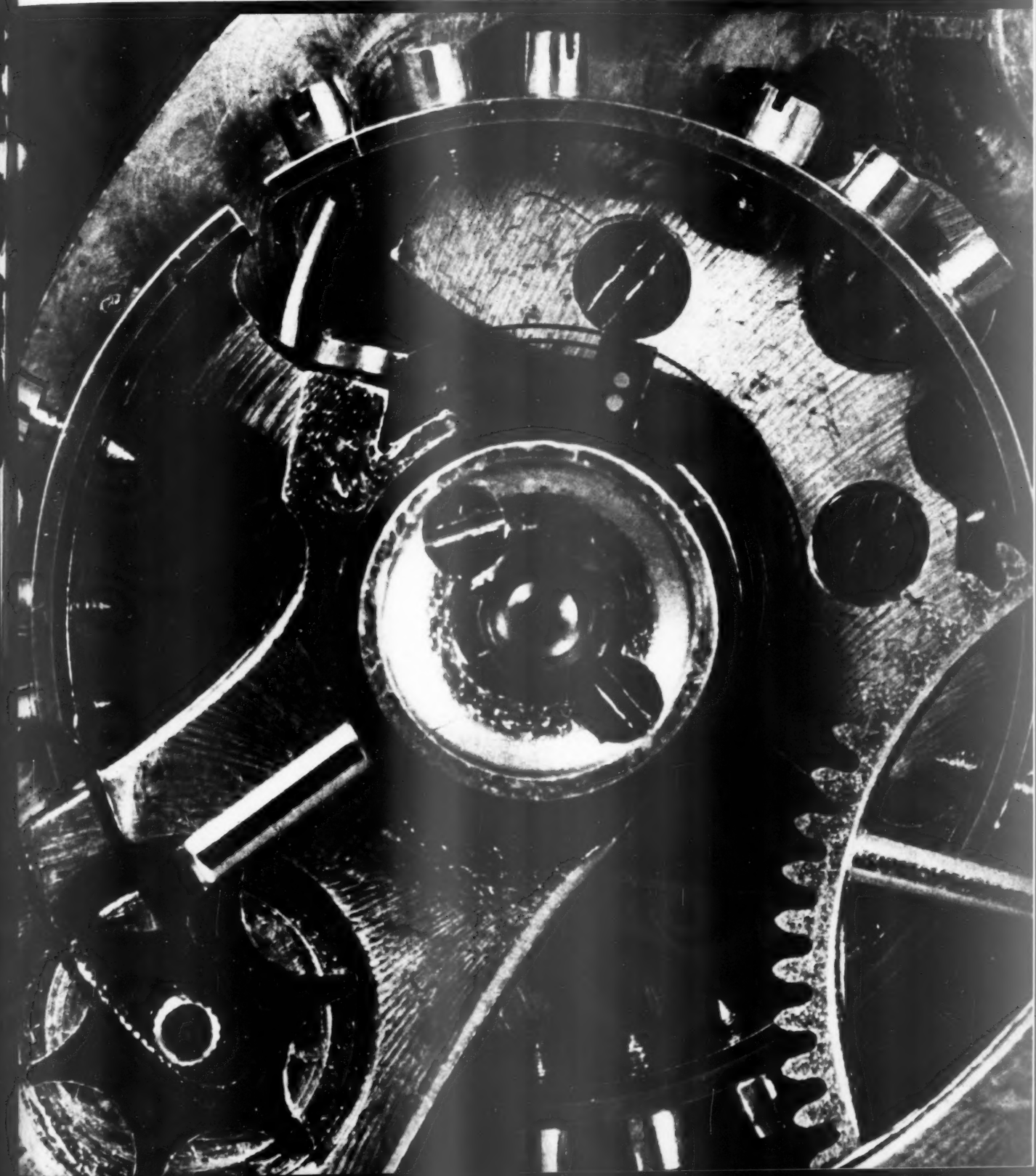

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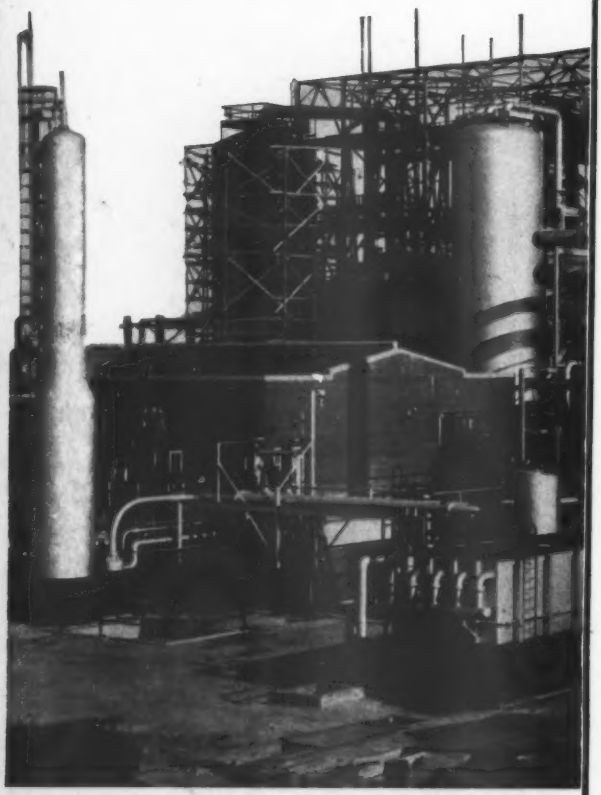

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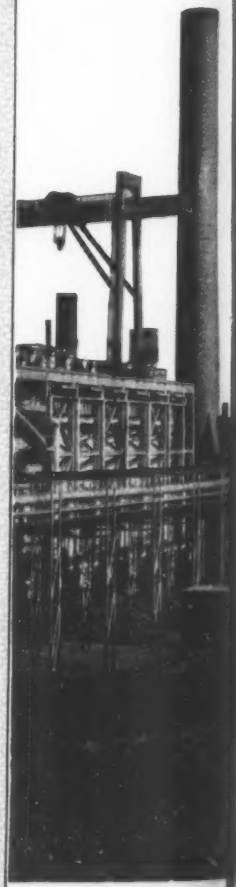

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THE TABULAR VIEW

Work. — What periodic dislocation of the economic system means has in the past been a subject monopolized by theoricians, statisticians, analysts, to be charted and tabulated mainly in terms of price movements, supplies of this or that, even sunspots. Our own times, however, have seen a shift in treatment, as in photographic studies of the submerged and the dispossessed. Economics has turned to direct discussion of the human beings involved in depression. ELI GINZBERG, who sketches research in the subject (page 150), has been on the staff of the School of Business at Columbia since 1935. He held the Cutting traveling fellowship from Columbia the year before, studying conditions in large-scale American industries. Dr. Ginzberg has published several volumes on economic topics and contributes frequently to journals.

Forward. — Designer of airplanes and airships, founder in 1914 of the Institute's pioneer course in aeronautical engineering, builder at M.I.T. of the first wind tunnel in this country, member of the National Advisory Committee for Aeronautics, JEROME C. HUNSAKER, '12, bears a distinguished reputation in aviation. His survey of technical advances in that field (page 152) is based upon his address as retiring vice-president of the engineering section of the American Association for the Advancement of Science.

Dynamic. — The crowded days of the Renaissance saw many modern activities attain to firm beginning stature. This was the period of the explicit formulation of the metallurgical art that earlier had been carried in the minds of its exponents — a reduction of ideas, a cupeling of concepts. CYRIL STANLEY SMITH, '26, research metallurgist of the American Brass Company, who is also historian and antiquary of the art, describes for Review readers (page 155) some of the principal events involved. A member of the Institute's staff in the year following his completion of graduate study here in 1926, Dr. Smith is a frequent and stimulating writer on matters metallurgical.

Millimicrocosmos. — A strange dimension of matter is that of the colloids, where properties change for reasons which must be ascertained by the remotest of remote control. As familiar as one can be with the elusive inhabitants of this region is ERNST A. HAUSER, Associate Professor of Chemical Engineering at Technology, who writes about them (page 158) with the authority of wide research. From Dr. Hauser's work resulted, among other things, the first commercial process for concentrating latex.

Groundwood. — Groundwork for the establishment of Canada's great paper industry drew on the abilities of her neighbor to the south, in an example of international co-operation ably reported (page 161) by J. N. STEPHENSON, '09, who, editor of the *Pulp and Paper Magazine of Canada*, medalist of the industry's technical association, knows well whereof he speaks.

Ticker. — To the Cover Club this month comes VERNON E. WHITMAN, '22, with an interesting magnification of what makes time fly.

No. 31

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A CHALLENGE

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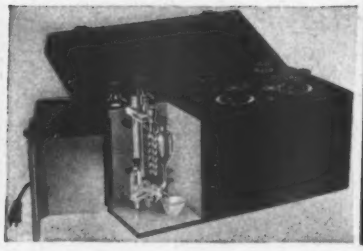

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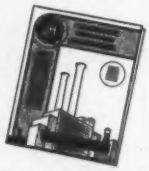

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MAIL RETURNS

Very Much Needed

FROM JOHN F. GUMMERE:

I have just read the article, "Linguistics as an Exact Science," by Benjamin Lee Whorf in the December issue of The Review. This is the kind of article which is very much needed, for there are relatively few people in the scientific world who know much of the work that is being done in the field of linguistics. . . . I congratulate you upon this very real and important contribution to an understanding of linguistic studies and hope that the author may be willing to write more.

Germantown, Pa.

That Cow Again

FROM M. J. KEOUGH:

In your Review of January, 1938, I recently came across the following answer to a brain twister about a cow tethered to a stake at the edge of a circular one-acre pond:

Let a be the radius of the pond, S the area over which the cow can graze, and w the angle formed by the tether in the two extreme positions of the cow on the shore of the pond. A little geometry then gives for S,

$$S = \pi a^2 + a^2(2\pi - w)\cos w + a^2 \sin w.$$

Since the area of the pond is one acre, and the area S must also be one acre, we must have

$$S = \pi a^2, \text{ or}$$
$$a^2 (2\pi - w) \cos w + a^2 \sin w = 0,$$

which reduces to $\tan w - w + 2\pi = 0$.

This transcendental equation can be solved only approximately. The approximate solution is $w = 1.790 = 102.56°$.

The length of the rope is given by

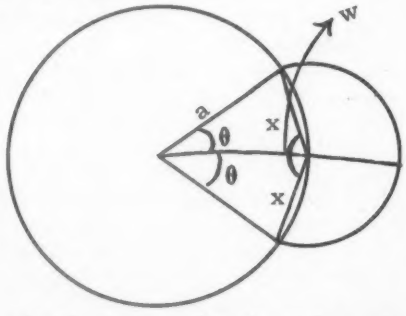
$$x = 2a \cos (w/2)$$
$$= 1.251a.$$

Since $a = 117.75$ feet, the length of the rope is 147.31 feet.

As I'm specially interested in thoroughly understanding the solution, I'd appreciate complete details as to the "little geometry" that gives the first equation.

Westmount, Quebec.

The "little geometry" to which Mr. Keough refers has been supplied to The Review by Professor Raymond D. Douglass, '31, as follows:



Let x = length of rope and 2θ the angle measured from the center of the pond to the extreme positions of the cow.

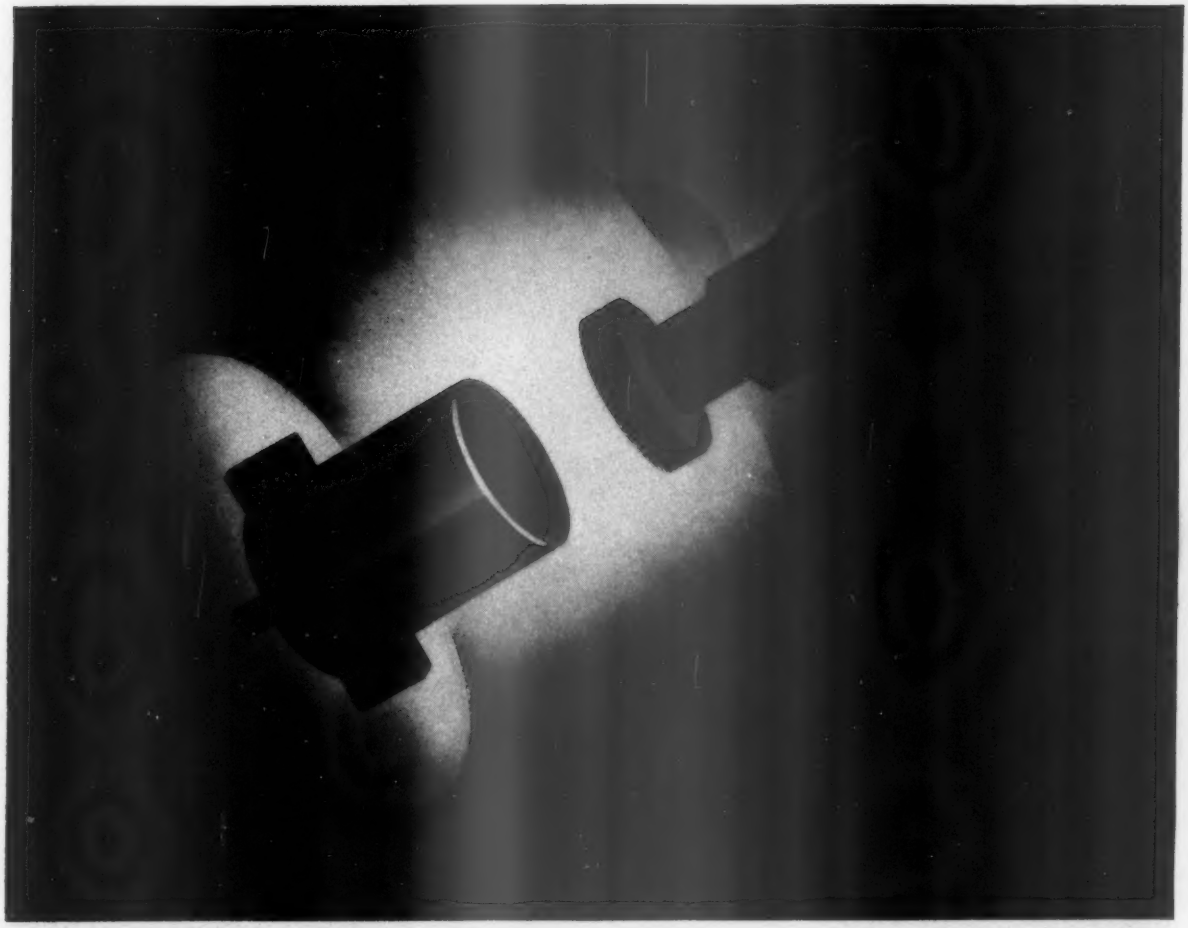
$$\text{Area} = \tfrac{1}{2}x^2 (2\pi - w) - a^2 (\theta - \sin \theta),$$

where $\theta = \pi - w$ and $x = 2a \sin \dfrac{\theta}{2} = 2a \cos \dfrac{w}{2}$.

$$\therefore \text{ area} = (\pi - \frac{w}{2})4a^2 \cos^2 \frac{w}{2} - a^2(\pi - w - \sin w)$$

$$= a^2 \left[4(\pi - \frac{w}{2}) \frac{1 + \cos w}{2} - \pi + w + \sin w\right]$$

$$= a^2 [(2\pi - w) \cos w + \sin w + \pi].$$



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Robert K. Phelan, '30

Sampans along the sea wall at Singapore

VOLUME 43 NUMBER 4

THE TECHNOLOGY REVIEW

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EDITED

AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CONTENTS for FEBRUARY, 1941

THE COVER — TIME AT 40X
From a photograph by Vernon E. Whitman, '22

PRECISION IN PRODUCTION . . . . . FRONTISPIECE 142

THE UNEMPLOYED . . . . . By Eli Ginzberg 150
Unemployment Is an Abstraction Expressed in Terms of Human Beings

TECHNICAL PROGRESS IN AVIATION . . . . . By Jerome C. Hunsaker 152
Results of Research Important to Defense

METALLURGY OF THE RENAISSANCE . . . . . By Cyril Stanley Smith 155
Expanding Activity in the Sixteenth Century Makes It of Great Interest

IN THE LILLIPUT OF MATTER . . . . . By Ernst A. Hauser 158
The Colloidal Range of Dimensions Can No Longer Be Neglected

FROM LOGS TO RICHES . . . . . By J. N. Stephenson 161
Canada's Newsprint Industry Profits from International Amity

☆ ☆ ☆

THE TABULAR VIEW 137
Contributors and Contributions

MAIL RETURNS 138
Letters and Pictures from Review Readers

THE TREND OF AFFAIRS 143
News of Science and Engineering

THE INSTITUTE GAZETTE 164
Relating to the Massachusetts Institute of Technology

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Precision in production—a gear grinder at work

THE
TECHNOLOGY REVIEW

Vol. 43, No. 4 February, 1941

The Trend of Affairs

Consols of the East

THE trade winds of war are blowing in the South Seas and the schooners and island steamers are on the move, for copra is booming again. This South Pacific staple harvest — the dried meat of the coconut, from which oil is extracted — was in great demand in the first World War, and now the cry for copra is rising after a period of several years during which production declined. On all the islands of the South Seas the copra knives are busy again. Thousands of natives squat under palms, slicing the nuts with machetes, stripping the white flesh from the brown husks to be dried by the tropical sun.

Every South Sea island, from Tahiti to the Solomons, has its coconut palms, and often the first indication that a ship is approaching land is the sight of floating coconuts. The coconut grew in the Pacific before man settled the islands, for the seeds were blown across the ocean from the East Indies long before the Polynesian migration brought inhabitants.

The coconut palm starts to bear when it is five or six years old and thereafter produces steadily for many years. Although sun-drying is the principal method for treating the copra in the Far East, artificial dehydration of the meat has been applied to a limited degree in recent years. This latter method, while the more expensive, is the better, for sun-drying is uncertain and the action of intense sunlight may decompose or destroy large quantities of the oil.

In the early years of the copra trade, native workers lacked the skill and equipment for extraction of oil, the coconut meat being generally marketed in the form of copra, which, when dried, is a hard, brownish substance. In recent years, however, oil-extraction plants have been built in the coconut regions. The method for the production of the oil requires that the copra be shredded and heated by steam to soften the tissue and liquefy the oil for extraction under pressure. After removal of the oil, the highly protein copra is converted into meal for cattle feed.

While coconut oil finds its largest use in soaps, shaving creams, and cosmetics, it is now widely employed in foods in the form of solid and liquid shortenings. The effects of war on the production of animal fats will no doubt greatly increase the use of this valuable vegetable oil for food, particularly as an ingredient of substitutes for butter.

The Philippine Islands, where there are at least eight large oil-extraction plants, produce most of the coconut oil used for food purposes, but the Netherlands, France, Ceylon, British Malaya, the Dutch East Indies, and Germany have exported the product. The United States is the leading importer, and tank ships which carry petroleum from the west coast of the United States to the Far East often return with cargoes of coconut oil, the total importation of which was nearly three million pounds in 1927. During the last war, when copra was in tremendous demand, prices reached the sum of $100 a ton. The demand continued until the world trade slump period of 1932, when prices for the material fell as low as $35 a ton.

Coconuts are literally meat and drink for many natives of the South Seas, and on some of the smaller islands which have no drinkable water the milk from young nuts is the only liquid for quenching thirst. The meat of the coconut finds its way into many native dishes, and excellent timber is made from the trunks of the coconut palm. The leaves of the tree provide thatch for the houses, matting for the floors, and costumes for the inhabitants. The tough fiber from the husks is used by the South Sea island natives to lash the roof beams of their houses and, writes Stanley Brogden in the *Christian Science Monitor:* ". . . The material is so

tough that the native houses will remain standing after a storm which has demolished most European-built houses." From the dried coconut meat, natives make an oil with which they anoint themselves after bathing. The oil is a salve which protects the skin from the sun and, scented with crushed flowers, is often presented in little pots as a gift.

For Burners of the Weed

LILAC, mountain laurel, mesquite from Texas, and the stout yew wood of England are by way of finding special place in the affections of man. They are prominent among the woods being considered as raw material in the manufacture of the bowls of tobacco pipes, for war has sadly decimated exports of traditional brierroot from France, Italy, and Algeria. Hope that Spain might become a source of good supply has not been realized, reports *Domestic Commerce*, since the quantity produced there is not large and the bulk of the exports must be paid for in foreign exchange at an artificially high rate.

For the past eighty years, the root wood of the white heath — in French, *bruyère*; hence the English "brier" — has made the bowls of many of the best pipes in the world. The wood is fine, is easily worked, and does not char readily. Commercial quantities of it are found in Spain, France, Italy, Corsica, Sardinia, Sicily, Greece, Asia Minor, and along the northern coast of Africa. These sources have been drawn upon since the discovery by a French firm in 1860 that the wood is well adapted to the demands of devotees of tobacco. For the root of the brier to grow to proper size for pipe blocks requires from twenty to sixty years. Skilled workers are needed to dig the roots, since judgment by age and size of the stems is the only way of determining whether the root is large enough to be worked. Extraction of the roots begins with the first rains of fall and ends in spring or early summer. Kept damp to prevent their being split by drying before they reach the factory, the roots are there sawed into blocks, which are boiled in water some ten or twelve hours as further insurance against splitting. Graded and sacked, the blocks next go to the pipe manufacturers.

Italy, chief supplier of brierroots to the United States since 1932, exported 12,000,000 blocks to this country in the first half of 1940 but only 302,000 in the four months following. Shipments from France and Algeria likewise fell off sharply. The Spanish possibilities are not very great, and recent price quotations on Spanish blocks are more than twice as high as normally. These are reasons which have set American foresters to speculating on the utility of native woods, such as the wild lilac of Oregon and California, which has large and frequent burls; and to considering a return to the mountain laurel, from whose roots the pioneers whittled pipe bowls in early American days. A fine-grained hardwood, native to the southern mountains of the eastern United States, the mountain laurel is a member of the heath family. It carves easily, withstands splitting, is slow to char, and darkens with age — in all these respects offering qualities like those which have made the brier famous — but it is not to be had in large sizes or great quantity. The Texas mesquite, however, is generously available, the area in which it grows being said to have more than doubled since Texas entered the Union. The

roots of the mesquite go farther beneath the surface of the earth than do those of any other tree known in this country, reaching at times depths of fifty to sixty feet.

In England, pipe manufacturers have experimented with yew, the first pipe made from which was smoked only an hour and a quarter after the initial manufacturing operation had begun. No flavor or tang impairing the pleasure of smoking, it was reported, was given off by the wood. English yew, which does not char readily and is smooth and light, closely resembles the western yew which covers a range of more than 1,000 miles from Alaska to California and grows east to Montana

A Ruth amid no alien corn is the Navaho woman shown at the upper right, gathering pollen for use in the prayer ceremonies with which these descendants of Athabascan raiders from the north greet morning and evening. Facing the east, the orthodox Navaho touches a pinch of pollen to the lips and the top of the head as ritual, the pollen symbolizing fertility and, by extension, multiplication of all good things. Directly above, the woman is shown holding a pouch filled with pollen. At the lower right, with the aid of her daughter, she milks a goat. Among these Indians, the men are great fanciers of, and dealers in, horses, which are their chief form of property in this matrilineal culture. The women own the homes and the flocks, which consist mainly of sheep.

On the opposite page, the Navaho woman demonstrates the process of spinning, which the Navahos adopted, with agriculture, from the Pueblos. She attaches a piece of carded wool to the spindle just above the whorl by moistening the wool with saliva. The spindle is then rotated between thumb and fingers, the forearm resting on the skirt so that the spindle points across the body. From time to time the twirling spindle is raised, as in the photograph, so that the spun yarn forms a mass adjoining the whorl instead of remaining wound the length of the stick. Navaho women spin at odd moments, much as white women knit, frequently carrying a spindle and a sack of carded wool with them when they go visiting. The accompanying photographs were made by Paul J. Woolf, who visited these Indians last summer with Clyde Kluckhohn, Harvard anthropologist.

Vernon Hoyer

Architectural detail of Palomar Observatory, California

from the Pacific Coast. This western species was the "fighting wood" of the northwestern Indians for the same reason that its British cousin was called the "shooter yew."

Rock Salt and Infrared

IF the ranges of the infrared spectrum are no longer a dark continent of science, they are still frontier territory, chiefly because instrumentation in this field is difficult. Many times broader than the visible spectrum, the band of infrared wavelengths extends from about 7,000 angstroms, where red shades into blackness, to the not too sharply defined point where the hertzian waves begin.

For the handling of infrared radiation the principal optical materials — glass and quartz — quickly become useless, since they are opaque to wavelengths beyond 25,000 or 30,000 angstroms. Exploration farther into the infrared requires the use either of certain salt crystals which are good up to about 250,000 or 300,000 angstroms, or of diffraction gratings, which are good indefinitely. Until quite recently, the infrared spectroscopists had to make use of natural crystals, which, because of limitations on size and purity, are not altogether satisfactory. The transparency of the salts can be greatly affected by small amounts of impurities, while the resolving power of prisms cut from the salt crystals — that is, the ability to separate closely spaced lines in the spectrum — is a function of the thickness of the prism. As prisms increase in size, analysis of beams of greater energy content also becomes feasible.

If the spectroscopist is to use prisms, his need for big ones is intensified by the fact that infrared radiation is invisible, so that charting of the spectrum must be done either with photographic plates, which at best will respond up to a paltry 13,000 angstroms, or with a thermopile. When the latter method is used, the radiation is changed to heat, the heat is changed to an electric current, and the current is recorded in one manner or another. Obviously, charting becomes a slightly easier problem as the intensity of the lines increases and the separation between them grows greater.

Scientific demands in such matters being insatiable, it would be incorrect to imply that the infrared spectroscopists are now happy, but at least they have been greatly aided by the commercial production of various synthetic salt crystals (the important ones to this field are sodium chloride and potassium bromide) in sizes up to eight inches in diameter and twenty-five pounds in weight. Such crystals are produced from their molten state by methods based on the work of Professor Percy W. Bridgman of Harvard and of Donald C. Stockbarger, '19, Associate Professor of Physics at the Institute. As a result, prisms have been cut with the hitherto unequaled dimensions of four to five inches in height and six inches in base length.

Infrared spectroscopy is primarily a means of studying molecular structure, as opposed to atomic structure. When electrons are excited, they emit radiation in the ultraviolet and visible regions, while the relatively deliberate movements of the much heavier atomic nuclei and of the molecules themselves produce wavelengths lying mainly in the infrared. It is this spectrum, therefore, which can tell how far a particular carbon atom is from a certain hydrogen atom, at what angle an atom of oxygen is tied to an atom of hydrogen, or whether a substance contains specific groups like C-H, C-N, or O-H. Together with the Raman spectra, which infrared spectra helped to interpret, this tool has stimulated anew the study of molecular structure.

The widest industrial use of infrared spectroscopy is in such industries as petroleum, plastics, and rubber. As a means of analysis, it possesses the usual advantages of the spectroscope in requiring only small amounts of material and of not harming them. In studying the changes that occur in drying oils, for example, the same film of paint has been analyzed repeatedly without damage.

Spaghetti to Stainless Steel

THE manufacturing process known as extrusion has long been applied to a wide variety of products, ranging from spaghetti to clay bricks to aluminum beams. Today, spurred by war needs, the British and

German metal industries have found valuable use for the extrusion of such items as stainless-steel tubing, and this country, too, is expected to witness soon the further application of extrusion to metals. The fundamental action during the extrusion process, whether for spaghetti or steel, is the forming of an elongated object by forcing a plastic mass through an orifice of the proper shape.

Extrusion of metals has important advantages and also, of course, some limitations. It competes with the rolling of metal beams and the piercing of metal tubes, and has had to show economic and technical superiority over those processes, for certain purposes, before taking its place among important production methods. Metal strips with cross sections too complicated to be obtained by the rolling or piercing process can often be extruded readily. Extruded metal frequently has better properties than does metal formed by other methods. An extrusion press lends itself much more easily to changes of product than does a rolling mill or a piercing mill, and for some products, like small stainless-steel tubing, extrusion appears to be inherently more economical than do other processes. Such advantages as these underlie the rapid broadening in the use of extrusion, an expansion subject to limitations which are constantly being reduced.

One limitation has been the high pressure required to force metal to flow through an orifice; hence the economical extrusion of strong metals, such as stainless steel, has awaited the development of equipment capable of handling sufficient pressure. Extrusion practice today, however, employs without difficulty pressures well in excess of 100,000 pounds a square inch. Another limitation has been the necessity for careful control of metal temperature during extrusion, but again progress has overcome the difficulties sufficiently for practical operation. Soft lead may be extruded at or near room temperature, but a temperature of about 800 degrees Fahrenheit is used for aluminum and one of approximately 2,200 degrees Fahrenheit for stainless steels, the allowable ranges of variation being narrow. Excessive wear of extrusion dies and tools has been another factor requiring consideration. The commercial success of extrusion thus depends on extremely careful planning and control, and its economical application to common steels is not even anticipated at present.

In this country the commercial extrusion of soft metals, such as lead, was introduced many years ago, after which the process spread to tin, copper, aluminum, magnesium, and other metals and their alloys. Typical extruded products are wire solder, small brass gears, lead sheaths for cables, and structural shapes of aluminum and magnesium alloys. Extrusion of such high-strength metals as stainless steel and Monel has been demonstrated in the United States on a small scale. Expansion to mass-production quantities may well follow as greater need develops.

Terminal Trouble

THE last census has confirmed the long-held opinion that when American urban populations now increase, they do so in the suburbs of the great cities rather than in the cores of the cities. In keeping with this trend are the steady and fairly general drift toward decentralization of the business and shopping districts in our big cities and deterioration of downtown property values. Chief reason is believed to be traffic congestion — and the main cause of traffic congestion is curb parking. A typical reaction to the problem was the announcement last month by the mayor of Boston — a city representative of the older ones, in which the traffic problem can be seen in its most virulent form — that he was seeking state aid for an elaborate program of highway and parking improvements to combat an alarming decrease in property values in the business area.

The problem, for which a completely satisfactory and generally applicable solution is yet to be devised, is inherent in automobile transportation and is but an aggravated form of the difficulties which have forced railroads to build enormous terminal facilities. An automobile, on the average, carries from 1.5 to 1.8 persons; a bus or streetcar, from 35 to 50. Traffic counts in business areas may therefore be expected sometimes

Detail of the Hatch Memorial orchestra shell, Boston

R. W. St. Clair, '36

to show that automobiles are representing perhaps 90 per cent of all vehicles while transporting about 40 per cent of the people. The automobile, furthermore, requires for parking more space than its driver needs for working: Office workers may require 150 square feet of floor area per person, but an automobile in a parking lot needs from 180 to 200 square feet and in an elevator garage it requires even more. And every driver knows how much of a street is left for traffic flow after a line of cars has been parked on each side.

To widen streets is expensive at best and virtually impossible at worst, as in old cities like New York, Philadelphia, and New Orleans, where narrow streets have long been solidly fringed with valuable property. A somewhat Draconian solution is to bar parking altogether on certain streets except for vehicles which are loading or unloading. New York initiated this plan about three years ago and eventually made about thirty cross-town streets into "express" highways, with the result that traffic speeds were at first almost doubled. Recent surveys have shown, however, that conditions have largely degenerated to what they were before the ban. It appears that unless automobile drivers are provided with convenient and reasonably priced off-street parking space, curb-parking bans cannot be effectively enforced.

The increase in off-street parking facilities is indeed a means — if a costly one from the parker's point of view — of easing traffic congestion. Such lots and garages can create a traffic problem of their own, however, unless they are located so that cars using them do not interfere with through traffic. Few cities appear to possess truly adequate space of this type. There is some tendency to compel owners of new buildings to provide inside loading and unloading space and to furnish at least a portion of their customers or tenants with off-street parking space. The parking meter, quite widely used, offers a relatively new means of discouraging lengthy parking. No scheme in sight, however, gives promise of great relief for the problem of what to do with the automobile once it gets where it's going.

Angles on Alcohol

DRINKING and driving, as has well been argued for some years, do not belong together. Latest addition to the data on this subject is conclusions reported by Donald S. Berry of the National Safety Council, who finds that in fatal automobile accidents 7 per cent of the drivers in 1933 had been drinking, 11 per cent in 1939. For pedestrians who drink, the increase was from 8 per cent in 1933 to 15 per cent in 1939. In one of every five fatal accidents in 1939, driver or pedestrian had been drinking; one in seven pedestrians and one in nine drivers involved in fatal accidents had been drinking. Drinking drivers are most frequently involved in collisions of two or more vehicles, and the drinking driver is usually at fault in this characteristic accident. Mr. Berry's conclusions were based on statistics gathered from city and state police and motor-vehicle departments in all parts of the country.

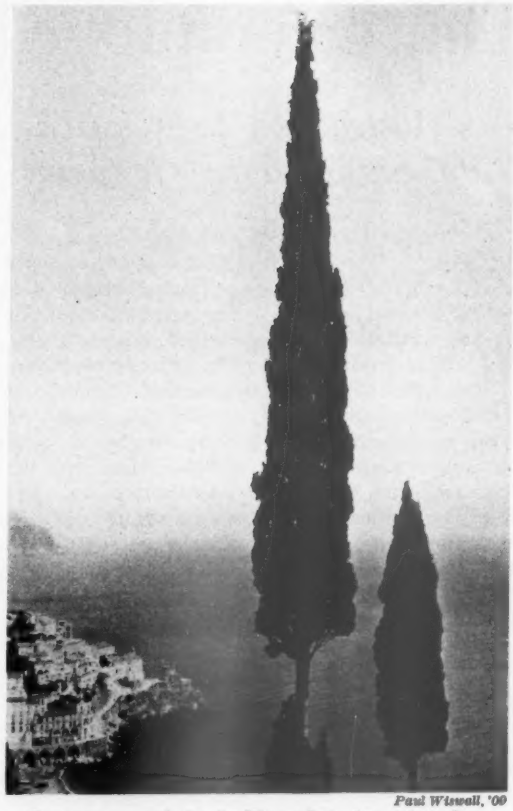
The demon rum has also been laced recently with something other than spices by speakers before the American Association for the Advancement of Science. The greatest present public-health problem not under scientific attack is that of alcoholism, according to Dr. Winfred Overholser. Its cutting of the vitamin B_1 margin of safety by increasing the intake of calories

Steiner from Black Star

Trees at St. Moritz in Switzerland bear strange blooms after a snowstorm.

was declared by Dr. Norman H. Jolliffe to be the reason why alcohol cannot be handled by present-day drinkers in the quantities to which their grandfathers were accustomed. Those of the earlier generations took in larger quantities of the vitamin in proportion to the calories consumed, and hence the extra 200 calories supplied daily by the potations of the average drinking American affected in less degree grandfather's vitamin balance.

Vitamin A in the body likewise appears affected by alcohol, according to a group of investigators at the University of Rochester. They find that the vitamin A content of the blood is raised by intake of alcohol, as in the "social" evening drinking common in this country, and suggest that the rise is probably due to a shift of the vitamin from other tissues of the body, notably the liver.



Paul Wiswall, '00

Cypress trees stab the sky like exclamation points, from the steep hillside above the famed former monastery of the Capuchins at Amalfi, Italy. Part of the town is at the lower left.

Hither and Yon

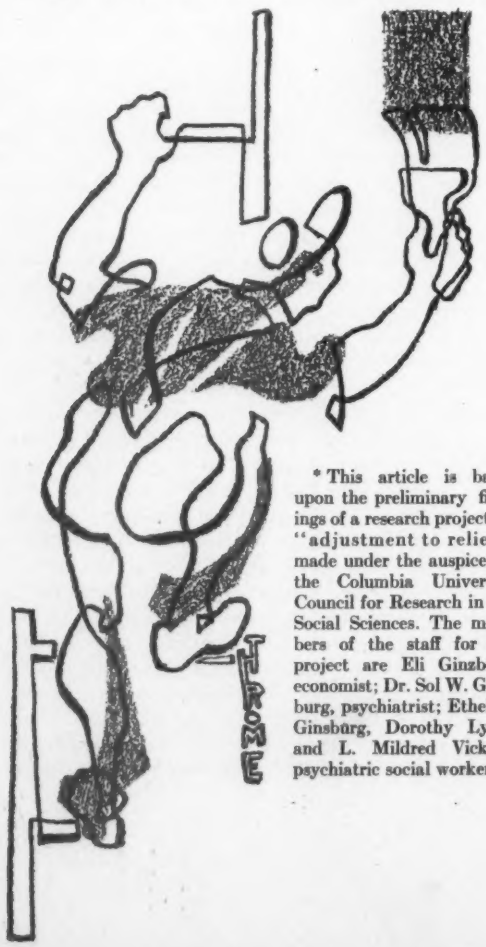
ROSES by any other name may smell as sweet, and roses may still be what the poet's luve is like a red, red one of, but they at present are being given still other assignments — large strips along railway lines in Germany are now planted to wild roses whose fruits are to be processed for vitamins to fortify German diets. The hip of the wild rose has been found to contain vitamin elements; hence in a world in which even the bill of fare must be fortified to meet martial needs, the twining eglantine becomes matériel. ¶ A rustproof magnet clips to the bottom of a shower curtain, clings to the iron of the bathtub regardless of enamel or porcelain, and keeps that curtain from wrapping around the bather or flapping up to let the shower drench the surroundings. ¶ Modernizing mugging, a talking motion-picture rogues' gallery has lately been patented. Portable sound-picture apparatus with a floor mat containing sockets to insure uniform placing of camera, microphones, spotlights, and graduated screen provides means of securing a record of mannerisms, voice, and appearance of the suspect, who is directed to pronounce particular phrases, go through certain motions, and walk in a prescribed area before the graduated screen which registers his size. ¶ Steel-terminal copper bonds are rated as probably cheaper and more dependable than other types for the task of protecting pipe lines against the corrosion resulting from the flow of weak currents of electricity from the metal of the pipe into the ground. Cathodic protection against such damage is secured when bridging of a good conductor extends across high-resistance joints in the pipe. Satisfactory performance, easy installation, and low cost are the requirements to be met by bonds intended to perform this bridging and thus to keep the line at the same potential. ¶ Immersion in warm water for six hours after soaking in cold water for an hour suffices to remove war gases from leather bookbindings, research by the British Leather Manufacturers' Association shows. Suspected books must be examined by gas-masked and rubber-gloved workers; from those contaminated the bindings are removed for treatment. After being rinsed and dried at the end of immersion, the bindings are replaced. If mustard gas has splashed the pages, it can be removed with chloride of lime solution on a swab of cotton. ¶ Concrete curbing cast with corrugated panels spaced at intervals along its upper surface gives the automobilist a constant indication of the edge of the highway. Illumination from the car headlights alone picks out the corrugated panels as a series of white blazes along the curb. ¶ The livers of sharks taken on the Floridian, Gulf, and Californian coasts are being processed for medicinal oils for the United States as Norwegian supplies of cod-liver oil are cut off; meanwhile in Germany the linings of the stomachs of large animals, generally used as food, is made into a satisfactory leather. ¶ The number of sizes of tin cans for meat products has been cut from 200 to 21 in Britain's effort to conserve tin. ¶ Glass springs, though more expensive to manufacture than are similar metal springs, are of particular value for light loadings in applications where resistance to corrosion or fatigue is important. A glass spring an inch and a half in diameter, designed to exert a force of approximately one pound at 3/32-inch deflection, showed no evidence of failure after many million deflection cycles in a corrosive sulphuric acid atmosphere. ¶ Hinges developed by a German furniture concern are made of plywood with cores of thin veneer and tough fiber, bonded with waterproof synthetic resin. No thicker than steel hinges, the wooden ones are fitted with either fiber or steel bolts. They have withstood tests of endurance involving 200,000 openings and closings. The veneer of the door panels is matched by the face veneer on the hinges. Fine-layer beech plywood faced with beech or other veneers and bonded with synthetic resin (*Continued on page 172*)

The Unemployed

Unemployment Is an Abstraction Expressed in Terms of Human Beings—a Condition Significant to Industry and Government

By Eli Ginzberg *

REPORTS that much-needed supplies to the United States Army are being delayed because of shortage in skilled labor are paralleled in the daily press by reports that several million families are still on relief. At present, only a few industries suffer shortages in skilled personnel, but as efforts are made to increase production rapidly, such shortages will become more prevalent. If our experience during the past months and Great Britain's experience during the past years be indicative, the stepping up of industrial activity will not eliminate unemployment. Today, Great Britain is making maximum efforts to utilize her available resources; yet the reabsorption of her unemployed into industry is confronting her with major and, to some degree, insurmountable difficulties. Despite the wreckage that cries for salvage and clearance, the British are at present supporting by public funds almost 800,000 families in which the head of the household is unemployed. And this is a new low, for even during the rearmament boom of the last years the number of unemployed seldom fell below one and a half million.



The persistence of unemployment in a period of rapid expansion in total employment is not easily comprehended, especially since statistics afford few clues and the majority of studies about unemployment have been statistical. The anomaly becomes less obscure when one recalls that a manufacturer contemplating expansion is more concerned with the availability of specialized laborers than with the general labor supply. He needs men who can operate a specific machine, adjust to specific working conditions, attain a specific rate of speed. The labor supply is a concept; laborers are human beings, and industry operates with human beings. So, too, with unemployment: Unemployment is a concept; the unemployed are human beings.

Unemployment has been much studied this past decade, for it has been a scourge second only to war. Most investigations, however, have dealt in generalities; few have been detailed. Recognizing that too little was known about the influence of unemployment upon people, the Columbia University Council for Research in the Social Sciences subventionized in the spring of 1939 a research project on the "adjustment to relief." The planning and execution of the investigation necessitated the pooling of specialized knowledge. The project is nearing completion, and certain findings suggest approaches to diagnosis and therapy of unemployment.

Approximately 225 families — all resident in New York City — were used for the investigation. From a sample so small and localized, it might appear unwarranted to draw inferences about a relief population of several millions scattered throughout the forty-eight states. Limitation of the study to families in New York City introduced only a minor bias, for the majority of Americans on relief live in urban communities. Careful selection and exceedingly painstaking control of the cases permit generalization of many, though not all, of the results. Clearly, the investigation shed little light upon problems of unemployment in rural or small urban communities, nor did it succeed in capturing all of the myriad aspects of unemployment in large urban centers. But this intensive case study clearly illustrates what unemployment does to people.

Every society, even the wealthiest, has misfits — the infirm, the indigent, and the aged. Excluded from the study were families in which the head of the household was severely handicapped for re-employment because of age, physical disability, or mental disturbance. Likewise, the exclusion of Negroes, Italians, Puerto Ricans, and other cultural groups helped to avoid the danger of ascribing to unemployment any difficulties of adjustment that lie elsewhere. Only Protestant-American, Irish-Catholic, and Jewish families were analyzed.

* This article is based upon the preliminary findings of a research project on "adjustment to relief," made under the auspices of the Columbia University Council for Research in the Social Sciences. The members of the staff for the project are Eli Ginzberg, economist; Dr. Sol W. Ginsburg, psychiatrist; Ethel L. Ginsburg, Dorothy Lynn, and L. Mildred Vickers, psychiatric social workers.

The range of the investigation can be gauged by the fact that approximately fifty thousand pieces of data relating to the families have been assembled, tabulated, and compared. From these data, one can suggest conclusions about what unemployment does to people and what government should do for the unemployed.

THROUGHOUT the last decade men have been more plentiful than jobs, a condition which does not explain why particular men are employed whereas others are not. Yet an explanation can be found. Many men on relief have difficulty in securing re-employment on account of age. Although a man seldom loses a job because he has reached his fortieth or forty-fifth birthday, application blanks of men in their forties are usually laid aside. Many such men are in mediocre health, and despite the fact that their disabilities would not interfere with work, they frequently interfere with the obtaining of work.

Many of the men, moreover, have lost their self-confidence and hence are unable to continue their search for jobs after years of trying and failing. Many are unable to secure assistance from their relatives or friends, for the majority of their relatives are themselves not self-supporting, and friends are few and poor. But the worst handicap is lack of skill and talent. Until the large reserves of young, able-bodied laborers (young adults in school, young men on the farms, the urban unemployed not receiving public assistance, employable women) are brought into employment, there is little reason to anticipate considerable reductions in the number of men on relief, men who for the most part are severely handicapped for private employment for reasons of age, health, morale, and family resources.

To appreciate the characteristics of the families on relief in 1941, it is necessary to recall that since 1929 the demand for labor on the part of industry has been insufficient to absorb the available supply. Many of the unemployed had their economic status undermined during the early 1930's, since which time they have been kept alive by makeshift arrangements, private and public. Their experiences since the loss of private employment largely explain their present demoralization.

Public relief became established in 1932, and from that day to this it has been a mixture of maintenance and work. Although the two approaches have much in common, they can be differentiated. The worst curse of unemployment — idleness — is the fate of recipients of home relief. Their budget allows for food, rent, and clothing, and an efficient housewife can usually protect her family from hunger and cold. But the budget does not provide work for the man, and work has always been part of his regimen. Muscles soften; latent emotional illnesses become overt; friendships with fellow workers are disturbed; long hours spent at home prove a strain on his wife; failure to earn wages lowers his prestige with his children. Loss of income is only a small fraction of the costs of unemployment. The idle man is without an outlet for his energies. He loses his friends, feels himself an outcast. To his deprivations is added the knowledge that the community views with opprobrium men without work, for our culture is intolerant even of millionaires who live in idleness.

Drawings by T. Hera Rome

Whatever be the shortcomings of work relief as administered in the United States during the past years, no fault can be found with the underlying conception that men should not be deprived of the opportunity to work. England wrestled with widespread and persistent unemployment throughout the last two decades, and though students differ in assessing her experience, they agree on one point: Relief without work is bad.

Of course, work as such is not always good. Little is gained by forcing a former bookkeeper to dig ditches, for such work does not preserve his skills and probably endangers his health. But work relief in the United States has, in general, contributed greatly to checking the evil consequences of loss of private employment. A man leaves home in the early morning and returns in the late afternoon. During the day, he has been engaged for the most part in useful work — work that has helped to keep his muscles toned and his skills sharpened. The job facilitates his making friends, and his wife and children continue to respect him, for his work is the basis of the family's support. Though the community says many bitter and foolish things about men leaning on shovels, work on the W.P.A. contributes to the maintenance of self-respect.

To develop and maintain an efficient program of work relief in an economy as complex and diversified as that of the United States is a herculean task. Small wonder, then, that even after years of experimentation all is not well. In general, governmental standards of discipline and performance are considerably below those of private industry. The government, however, is severely handicapped in the wages that it can offer and the promotions it can grant. Fifty-two dollars and fifty cents a month is hardly a wage that calls forth the best from a man, especially from a man accustomed to more.

Few indeed are the men on home relief and on work relief who find pleasure in their daily life, since they lack so much that is essential. There is enough food, but not of the right kind. Many a parent goes without meat in order that a child can (*Concluded on page 170*)

Technical Progress in Aviation

Results of Research Have Speeded Improvement During the Decade, with Consequences Important to Defense

By Jerome C. Hunsaker

THE increasing importance of the airplane in our normal social and economic life is just now overshadowed by the dominant role of the airplane in our national security. With recent advances in the aeronautical sciences being tested on a grand scale in the proving ground of war, we naturally lose interest in the possibilities of those same advances as they might apply to our peacetime communications. If we hope to live in a world in which individual living is worth while, our thought must be focused on the airplane as an instrument of power — destructive or protective.

That important technical progress has been made in the development of the airplane is obvious from the reports of dive bombings, night bombings, and aerial torpedo attacks, on the one hand, and from the reports of effective defensive action by fast fighting planes, on the other hand. Guns, armor, radio, fuels, meteorology, metallurgy, and photography are also contributing, through technical advances, to the effectiveness of the airplane in war. Attack and defense for colossal stakes have naturally stimulated development in every branch of applied science.

Technical progress in the development of the airplane has been especially marked in the past ten years. Some steps in the progress have been abrupt, because they were the consequence of inventions. True inventions are unpredictable, but experience has shown that when new knowledge obtained by research and experiment becomes generally known, the invention necessary for the practical application of the knowledge soon follows. Whether designers can then apply the invention to realize a technical improvement in the airplane depends on whether the state of the art is ripe for the advance.

For example, although the aerodynamic advantages of an unbraced monoplane wing were demonstrated by Fokker in the days of braced biplanes, the safe construction of such wings had to wait for the availability of light aluminum alloys. Likewise the advantage of retracting the landing gear and wheels was recognized at an early date and mechanisms for retraction were invented, but no designer would bother with them until speeds were high enough to make acceptance of the added cost and complication worth while. The designer of transport planes, moreover, needed a thick cantilever wing to afford space enough to house the wheels in the retracted position. The result was a lag of some ten years in the general adoption of this improvement.

Though some technical improvements are thus proposed before the art has advanced sufficiently to permit their use, others come about as a result of difficulties created by advance in the art. When airplanes fly very fast, for example, roughness of their external surfaces is found to be extremely costly in power. As a result, we now have flush rivets, spot-welding techniques, and other means to help make a smooth wing. Another example is the mass balancing of control surfaces to

Curtiss-Wright Corporation

"ON THE LINE"

. . . America's latest additions to its air-defense program — three of the fast, highly maneuverable Curtiss P-40 advanced pursuit planes, which are now being produced in the recently expanded Buffalo, N. Y., factory of the Curtiss-Wright Corporation, in accordance with a record peacetime order from the War Department

prevent unstable vibration, or flutter, of cantilever wings. Serious flutter trouble was not encountered until experience was had with high-speed monoplanes and particularly with dive bombers. The cure was discovered after the trouble was disclosed.

In general, then, the results of methodical research and experiment lead to new knowledge and to technical progress. Technical progress of itself, however, discloses new difficulties the solution of which requires further research. From the solution of them, additional technical gains may in turn result.

Under the stimulus of war, self-generation of technical advances is unnaturally accelerated, but the direction of the progress is likely to be toward immediate objectives. For fighting planes every effort will be made to improve the vital performance characteristics of speed and climb, regardless of expense in power and fuel. Bombers must take off with a maximum load without regard to the problem of how such an overloaded plane can safely be landed again. The assumption is that the bombs will be dropped somewhere remote from the home field or the fuel will be consumed to lighten the plane before landing.

The design of military airplanes is fundamentally controlled by military requirements and will be specialized as the requirements are specialized. Thus we have heavy bombers of long range to carry very heavy loads, light bombers of high speed, dive bombers and torpedo planes with special features of control, intercepter fighters of extreme speed and climb but short range, and escort fighters with long range and improved armament. Airplanes like these are not very well adapted for the economical transport of passengers and goods; yet the knowledge of the aeronautical sciences which makes such planes possible can be applied to the design of commercial airplanes. From the technical advances now being made in military aircraft, corresponding advances in civil aircraft for our air lines may safely be forecast.

Curtiss-Wright Corporation

Shown here in flight is the new Curtiss Tomahawk pursuit type. This is the British version of the Curtiss P-40 pursuit, designed for high-altitude combat.

Without any invading of regions of official secrecy, it is evident that progress is now being made in certain aspects of aeronautical science and that one is justified in venturing some opinion as to the general nature of future technical improvement in both military and commercial aircraft.

To begin with, we must realize that the airplane is the creature of the internal-combustion engine. The gasoline engine of the beginning of our century made possible both the automobile and the airplane. Progress in the latter has paralleled the technical development of its engine. The most spectacular improvement in the engine has followed better knowledge of the nature of the combustion of the fuel in the cylinder. From such knowledge came scientific methods for testing the octane number of a fuel as a measure of its detonation characteristics. Midgley's introduction of tetraethyl lead to raise the octane number has permitted engine designers to go to higher compression ratios, with consequently improved power and economy. Military aircraft must have fuel of the highest octane rating procurable; military pressure will create additional capacity for such special fuels and will stimulate the production of fuels of even higher octane rating than the best now available. Likewise, the national defense program is requiring engines capable of both increased power for take-off with large bomb loads, and increased economy in order to obtain a longer radius of action. The new engines must use the improved fuels in order to fulfill these requirements.

Obviously our air lines will become eventual beneficiaries of the bigger and better engines and the fuel to go with them. The commercial industry could never afford to subsidize the fuel and engine development costs that are involved. With more powerful engines, the Army will develop long-range multiengine bombers and the Navy long-range multiengine flying boats. These aircraft, of course, will not be equipped for passengers, but requirements for habitability for their crews will force consideration of adequate heating and insulation, soundproofing, deicing, radio communications and navigation, and special arrangements for substratosphere flying. For large military craft suitable tires, wheels, brakes, servo controls, and many types of special navigational and radio equipment which do not now exist will have to be developed.

Our designers and manufacturers, as a result of their experience with the defense program, should be in an excellent position to adapt the new aircraft for commercial purposes. The military planes may be too fast to be economical and may have take-off and landing characteristics unsafe for immediate conversion to air-line use, but the designer certainly will know what alterations are needed. The basic technical problem and one solution of it will be known. Then the designer will have only to work out a new solution making use of a proved method.

Another field in which rapid technical progress is being made is the aerodynamics of the airplane itself. This work, done in order to obtain higher speed from the same power, is all to the advantage of the air-transport operator, who must lower his costs and his fares as his business grows.

The reduction in drag by the use of smoother surfaces exposed to the air has already been mentioned. Roughness of surface is associated with the breakdown of the initially smooth laminar flow of air in the boundary

layer next to a surface. The alteration of laminar flow into a turbulent region of much higher drag is delayed if the pressure gradient along the chord of a wing is falling. Shapes of wing section in which the pressure gradient is more favorable to the maintenance of laminar flow are being studied. By the use of new wing sections made very smooth by modern techniques of fabrication, substantial reductions in drag may be expected to be realized in future.

One of the largest sources of wasted power, or drag, comes from the necessity for cooling the engines. The liquid-cooled engine must have a large radiator, and the air-cooled engine must have a strong flow of air over its cylinders. Recent research has shown that the drag of the cooling air can be very much reduced if the principles of fluid mechanics are applied to the ducting system that leads the cooling air into and out of the airplane. In addition to the direct cooling of the engine, moreover, an internal air flow is required for the carburetor and the oil radiator and also, if the airplane is designed for high altitudes, for the intercooler of the supercharger.

Courtesy Aviation

A British Spitfire in flight

An internal-combustion engine, of course, develops power from the combustion of fuel in the air that fills the cylinder. At an altitude of about 18,000 feet, the oxygen content of a cylinder full of air is only half of that at ground level; consequently only half as much fuel can be burned in this lighter air. The power of the engine therefore falls off very rapidly with altitude unless the engine drives a compressor or supercharger to supply itself with air at ground-level pressure. The supercharger heats the air adiabatically as it compresses, and the air is further heated by the turbulence and eddies created by its passage through the supercharger. In order to attain ground-level conditions in the cylinder, a radiator, called the intercooler, is required to cool the compressed air before it passes into the engine. Drag caused by the intercooler means wasted power, and the power taken from the engine to drive the supercharger is also wasted as far as carrying pay load is concerned. Present efforts to improve the efficiency of the supercharger as a pump should be helpful, and very real savings can be made in the ducting of the air. An alternative solution, which saves the power taken from the engine to run the supercharger, is obtained if the latter is driven by an exhaust gas turbine. Such turbines spin faster as the airplane goes higher and have ideal characteristics for the purpose. The turbine is an extremely difficult apparatus to make, however, since it must run in very hot gas and at very high revolution.

Acme

A Messerschmitt Me-109, fighter plane of the German air force

The national defense program will inevitably do much to bring about technical progress in supercharging, gas turbines, and associated control apparatus which our air lines badly need when they fly "above the weather."

Another aspect of the effort to get high-speed results is belated attention to the energy of the exhaust. This energy is about equal to that developed usefully by the engine. When airplanes flew at 200 miles an hour at moderate altitudes, the exhaust problem was merely one of disposal. If no flame blinded the pilot and no gas got into the cabin, disposal was satisfactory. At high altitude and high speed, however, considerable forward thrust can be recovered by passing the exhaust out through suitable nozzles. This, in effect, is "jet propulsion," long known to be a very uneconomical scheme at ordinary speeds. At high speeds the jet is really effective, and efficiency is of little consequence since the waste energy of the exhaust is being used. As much as a 10 per cent gain in effective thrust of the engine is estimated to be

(*Continued on page 178*)

Metallurgy of the Renaissance

Expanding Activity in the Sixteenth Century Makes That Period of Great Interest in the History of the Art

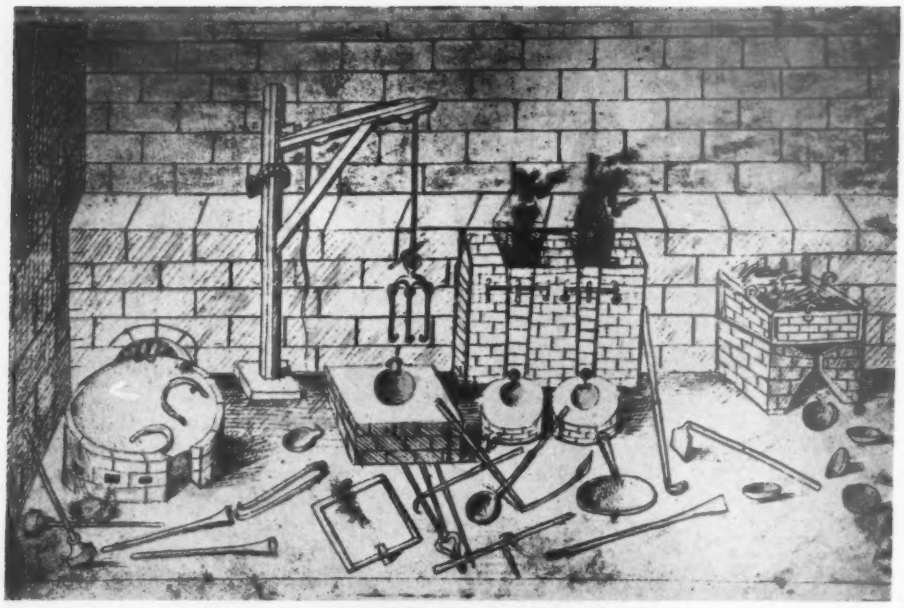
By Cyril Stanley Smith

In the history of metallurgy the Sixteenth Century stands out as a period of great interest. The activity in political and cultural fields was paralleled in the metal shops, and from this period date the first detailed descriptions of metal-smelting and metalworking processes. There are no books on metallurgy among the incunabula. This fact is not surprising: Printers then, as now, were meeting the popular market. The great demand was at first for theological works and, as the Fifteenth Century reached its close, for reprints of the classical authors on secular subjects. To be sure, the monkish metalworkers had their manuscript copies of the Tenth- or Eleventh-Century treatise by Theophilus to guide them in making their works of art for the church, and notebooks must have been kept by the more educated lay founders and smiths, but any such records were jealously guarded and did not become public property. Between the Tenth and Sixteenth centuries, therefore, no additions to metallurgical literature were made. Nevertheless, when metallurgical knowledge did come into print in the Sixteenth Century, it showed a considerable advance over the state of the art depicted by Theophilus; in fact it had developed to a point where relatively few changes were to be made for a further 150 years — years when the sciences of chemistry and physics were burgeoning with new life.

The thimblemaker, a woodcut by Jost Amman, 1568, showing the use of punch and die in a simple cupping operation

Despite the absence of written record, these five hundred years saw considerable activity. By the process of trial and error, by purely practical research, basically sound metal smelting and treating processes had been developed. The use of power was more common in smelting metals than in working them. Metals that had been smelted and refined with power-blown blast furnaces, from ores crushed under water-driven stamps and washed by machines of fairly large capacity, were turned over to the coppersmith, the armorer, the card and buckle maker to be finished by hand. Mineral resources were often regarded as crown property, and the operation of mines necessitated large expenditures of capital. The demand for profit, becoming insistent in the Sixteenth Century, caused ever greater emphasis to be placed on making processes efficient, and the scale of operations naturally became larger as capital for the necessary machinery became available. The limited occurrence of the ores concentrated smelting activity into a few locales, but the metalworkers were as widespread as the market and, with little thought of the advantages of large-scale operation with power, continued to supply local demand. While the prince wanted a good supply of gold and silver for coinage, the domestic tools and the utensils of the common man were of no concern to him, and even arms were largely the problem of his subjects, who supplied their soldiers already equipped. These factors favored small-scale operation once the metals had been reduced. Even in the cities where there was sufficient business to warrant improved methods, they were rarely adopted, perhaps because of the conservative spirit of the guilds.

It is remarkable what intense specialization was permitted or encouraged. Medieval English surnames indicating occupation include many related but distinct names, such as Wirdragher, Nedlere, Pinnere, Nayler, Spiker, Reverter, and Douler. All but the first represent simple tasks involving much the same skills. Occasionally subdivisions of the production chain may have been made nominally for the protection of the public. In Coventry a city ordinance adopted in 1435 forbade more than one of the trades of smith or drawer of coarse, medium, or fine wire to be practiced by any one man or association of men. Otherwise the smith might make some bad iron but would pass it to the brakeman for coarse wire drawing with instructions that it must be "tendurly cherysshet," the result being some wire with hidden defects. In the words of the record in the *Coventry Leet Book*, if this be made into fishhooks "for febulness hit all-to brekithe, and thus is the ffissher foule desseyued to hym grete harme." Or instead of making fishhooks, the wire might have been drawn by the girdleman and card wiredrawer, who used it even though they knew it to be bad, to the great harm of the clothmaker using the cards. If, on the other hand, the successive stages of the process were done by independent men, each would refuse to buy material unless it were of good quality.



Interior of a smelting house, from a manuscript dated 1480. Mixed copper and lead ores were smelted in the blast furnaces (center). The copper-lead cakes were heated in the liquation furnace (right) to allow the lead to run off, bearing the precious metals. The lead was then cupeled in the hearth at the left to give auriferous silver.

The earnest but misguided efforts of the alchemists in their study of metals had in the course of a thousand years produced singularly little of value to the science or practice of metallurgy. Many hundreds of alloys, many of which were potentially useful compositions, must have been made, but the alchemists were concerned only with duplicating the superficial qualities of the precious metals, and at best the copper-zinc alloys which resulted from heating copper with some of their rare mixtures were regarded as being an inferior gold instead of a greatly improved copper. Although the alchemists based their experiments on theory in a scientific manner, they unscientifically refused to discard the theory when experiment failed, and blamed rather themselves, often hiding failure and falsely claiming success or inventing ingenious alibis. The methods of parting gold alloys with nitric acid or with sulphur or antimony sulphide were perhaps born in the alchemist's laboratory, but little else was produced there.

The development of reduction-metallurgy methods prior to the Eighteenth Century took place almost entirely without the benefit of any satisfactory chemical theory. By 1500, methods were established that were so far ahead of the chemistry of the period that it was not for two centuries that chemistry, undergoing rapid growth all the time, began to make contributions to metallurgy.

The most striking evidence of this fact is that books written in the Sixteenth Century were still being reprinted in the Eighteenth Century as useful, sought-after texts. Important books on chemistry and physics were rapidly outmoded as a result of their own stimulus, for these were living, growing sciences. Metallurgists, in a purely practical way and without knowledge of why, had built up a series of operations that worked. Although at first unhampered by erroneous theory, metallurgy lacked a rational theory to accelerate development. If practical metallurgy was far ahead of theoretical chemistry in 1500, it had changed little by 1700, and the development of chemistry outstripped it. In the Middle Ages the learned men of church and university were concerned with trivial theological disputations; the artisans were the scientists. The revival of science occurred only when the men of the universities began to follow the method that had always been used by the men in the workshop. If scholars were then able to contribute more, it was mainly because they were used to keeping and publishing systematic records so that the lessons learned in one generation and locality could more quickly be passed on to other people in other places.

Typical of the alert practical metallurgist of the Sixteenth Century is Vannoccio Biringuccio, whose *Pirotechnia*, published in Venice in 1540, is the first book to deal with the whole field of metallurgy. Though he gives the first description of many metalworking processes, he does not claim to have originated any methods. He is insistent on profit and recommends metallurgy as a safer way to acquire wealth than is soldiering, and as a pleasanter way than that of the merchant with his uncomfortable voyages to foreign and frequently unfriendly shores.

Mining may be dangerous, he says, but only to your hired assistants. Large-scale operations are advisable, sometimes necessary, and adequate capital must be available in order to avoid having to drop an undertaking just as it approaches the paying point. In describing metallurgical operations, he tells the methods he has practiced and the materials he has found to work well, but always advises trying whatever materials are handy: Ram's-horn ashes may be best for cupeling hearths, but try whatever ashes are most plentiful in your locality; a specific clay is good in making molds, but try that of your local clay pits, if necessary blending several kinds to get the proper qualities. Never guess but always weigh materials and products; the assay balance and pen for computation are as necessary as furnaces.

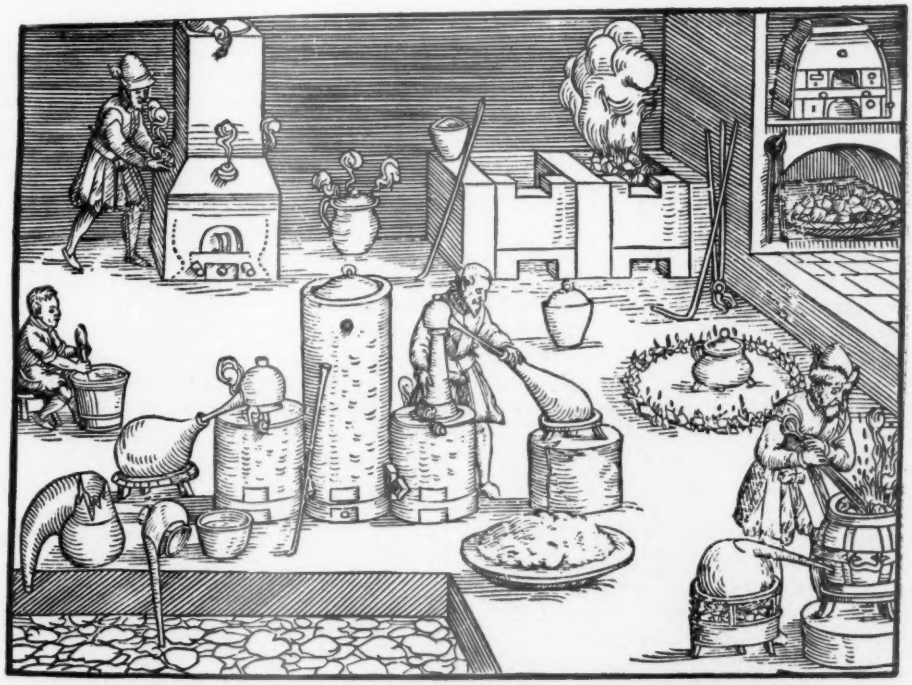
While Biringuccio can hardly be said to represent the modern approach to science via reasoned experiments planned in accord with rational theory, his is essentially the Edisonian approach, and he advises trying out everything to see what happens, making use of the one useful result of a hundred trials. This approach is in

sharp contrast with the method of the alchemists, who were applying the scientific method and who failed only by having too much faith. A period of ad lib. but controlled and observed experimentation is a necessary forerunner of the theories that are followed by more rapid and methodical advances, and the practical metallurgists following Biringuccio's ways provided much of the information upon which Boyle, Stahl, Lavoisier, and others built chemical theory. Indeed, had the chemists paid more attention to the increase in weight of lead on calcination (well known to the metallurgist) and had they used the balance in all their operations as the metallurgist did — for financial reasons to be sure, but nevertheless with the knowledge that reactions were quantitative, whether in a small assay or a large furnace charge — the idea of fixed reacting proportions would have carried its meaning in terms of the atomic theory far sooner than it actually did.

The very first printed book on metals deals with assaying. This is undated, but the British Museum catalogue suggests that it appeared in 1510 in Augsburg. It is concerned almost entirely with gold and silver and contains many recipes for making cupels, mixtures for cementation, parting with acid and sulphur, and various other tricks useful to the goldsmith. Several separate systems of assay weights designed to avoid calculation are described in terms of the many different local systems of weights then in use.

In a series of "Books of Secrets," published after 1530 under various titles, are found many recipes for parting, refining, and coloring gold and silver; for numerous solders, fluxes, and molding compositions; for quenching mediums for steel. The important authors are, however, Biringuccio (1540), Agricola (1556), and Ercker (1574). Agricola's *De Re Metallica* is so well known that it needs little comment. It is a competent description by an intelligent man concerned with recording all operations in the mining, dressing, and smelting of metallic ores. Agricola ends his discussion with production of the metals and tells nothing about their use. Fortunately this field is covered by Biringuccio, who, from a lifetime spent in the forge and foundry, was well qualified to describe in detail processes such as the making of guns and bells, wire drawing, and making of castings small and large, useful and ornamental. Although both Biringuccio and Agricola have clear descriptions of assaying, Ercker, in his *Beschriebung Allerfürnemsten Mineralischen Ertzt und Berckwercksarten*, deals almost exclusively with this process. He tells how to make weights and balances, explains how to take good samples, and gives full instructions for distilling nitric acid, for making muffles and cupels, and for using them. Ercker's book has had the longest period of usefulness of any strictly metallurgical book. Published first in 1574, it was reprinted in 1580, 1598, and 1629, and, with notes and a new title — *Aula Subterranea* — but otherwise unchanged, in 1672, 1684, 1703, and 1736. English translations appeared in 1683 and 1686, and a Dutch translation in 1745. The 1580 edition was beautifully illustrated, and the woodcut blocks were preserved and used for all later German editions. The spread of time between the first and last editions is remarkable. It is impossible to conceive of reprinting for use today a technical book written before the War of Independence, yet Ercker's book was still in demand as a useful text 171 years after he wrote it.

The principal metalworking operations in use in the Sixteenth Century were much the same as those of today. Castings were used more commonly than now, and worked objects were generally made with a hammer, depending on the smith's judgment for dimensions and design. Quantity production of small objects like buckles, pinheads, and so on was achieved by casting from a multiple pattern, the pattern often being made of metal and forming the complete (*Continued on page 174*)



The assay laboratory (Ercker, 1580). In the back are (left to right) a cementation furnace, wind furnaces for crucibles, and a muffle furnace. The furnace in the right foreground is for copper assaying and is blown by an aeolipile. The athanor (middle foreground) is making acid for parting. The towers of the athanor and the cementing furnace are full of charcoal, which burns only at the bottom and falls down as it is consumed, thus maintaining a steady fire, without attention, for as much as a day.

In the Lilliput of Matter

The Colloidal Range of Dimensions, Marked by Sudden Changes in Property, Can No Longer Be Neglected If Progress Is to Continue

By Ernst A. Hauser

Ninety-Six Million Million Edges and What They Mean in the World of Lyocrats and Electrocrats — From Drinkable Gold to the Brewing of Beer as the Elusive Colloids Have to Do With Each

JUST about one hundred years ago, several leading chemists studying precipitation reactions of compounds insoluble in water, such as arsenic trisulphide and Prussian blue, observed that when they used low concentration of reactants, no precipitate apparently formed. The liquid took on the color characteristic for the normal precipitate but otherwise remained perfectly clear and transparent to the eye of the observer. Berzelius, the only one who tried to explain the paradox, assumed the particles of the formed precipitate to be very small and transparent. Solutions of that type were termed "pseudosolutions." It then became evident that the clear but vividly colored solutions of precious metals (*aurum* and *argentum potabile*) which the alchemists had prepared and for which they claimed exceptional healing power, must be classified in the same group; for these solutions had been obtained by the reduction of a dissolved gold or silver salt to the elementary and therefore water-insoluble metal.

In 1857, Michael Faraday demonstrated visually a striking difference between a true solution and a pseudosolution. If a concentrated beam of light is shot through the former (in a darkened room), its path through the liquid cannot be detected, but if a pseudosolution is substituted, one can clearly observe the passage of the light beam. This is the same phenomenon we witness in a moving-picture theater when we see the cone of light travel from the projector booth through the air onto the screen. Milliards of particles, suspended in the liquid or in the air, reflect the light impinging on them but are too small for the human eye to record. In 1861, Thomas Graham, studying the rate with which a solution of a water-soluble substance would diffuse, or distribute itself, into a volume of pure water, noticed that matter which has the aptitude to crystallize diffuses rapidly, whereas more gelatinous substances, like glue, either diffuse very slowly or not at all. Having found other substances which behaved "like glue," he coined for them the term "colloid," derived from the Greek expressions *kolla* for glue and *o-eidēs* for alike. In contrast thereto he named rapidly diffusing ones "crystalloids." The difference in rate of diffusion which Graham observed was first attributed to a difference in size between the colloidal particles and those constituting a true solution. This reasoning and Zsigmondy's development of the ultramicroscope (1903), which for the first time enabled us actually to detect the presence of discrete individual particles in a colloidal solution, resulted in the still frequently prevailing belief that colloids are nothing but extremely small particles suspended in a fluid.

This belief, however, takes into consideration only part of the picture. If we roll and hammer a piece of gold until it becomes so thin that we can no longer see its thickness with a regular microscope, and if we hold this film of gold against the light, a surprise is in store: We can see through. There is no distortion, but all is bathed in a beautiful green color. The solid gold has become transparent, and we are reminded of Berzelius, who assumed particles to be very small and transparent in certain solutions. In mentioning the drinkable gold of the alchemists I referred to the great healing power attributed to this preparation. Whether we believe such an attribution to be sound, we do know that most catalysts increase in activity with decreasing particle size, reaching a maximum in the colloidal range. Many other properties could be listed which exhibit pronounced maxima or minima as soon as the substance, like our transparent gold, has been brought to very minute dimensions. Can we offer an explanation for such sudden changes in property?

The smallest dimensions which we can resolve with a regular microscope are 1/1,000 of a millimeter, or one micron. Simple chemical molecules which diffuse rapidly will be at least a thousand times smaller — 1/1,000,000 of a millimeter, or one millimicron. This dimensional range, in which matter exhibits specific properties, is termed the "colloidal range of dimensions." Colloid chemistry is the study of the properties of matter present in the colloidal range in at least one of its three possible dimensions. According to this statement, colloids may not be regarded as a specific group of substances but rather as a general state of matter. If only one dimension is involved, we speak of

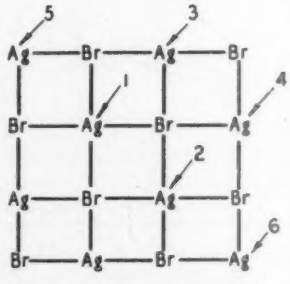


Fig. 1. Schematic crystal plane in an ionic lattice (silver bromide)

laminar disperse systems; if two, the systems are fibrillar; and if all three are affected, we are dealing with corpuscular disperse systems.

What these dimensions mean is suggested by an example: If we take a cubical crystal of, let us say, one centimeter edge length, it will have a volume of one cubic centimeter and a surface of six square centimeters. It will have twelve edges and eight corners. If we subdivide it into cubes of one-half micron edge length, a division corresponding to corpuscular dispersion, we shall have produced 8,000,000,000,000 cubes. Their combined volume will have remained one cubic centimeter, but their over-all surface will have increased from six square centimeters to twelve square meters. They will have a total of 64,000,000,000,000 corners and the staggering sum of ninety-six million million (96,000,000,000,000) edges. If we further take into account the fact that a difference in chemical saturation exists between an ion located in the interior of a structure, let us say a crystal, and an ion located at its surface, we immediately shall realize the importance of such surface developments. Take, for example, a plane in an ionic lattice (Fig. 1). The silver ions Nos. 1 and 2 are fully balanced by four bromide ions in the same plane; the silver ions Nos. 3 and 4, located in edges, are one bromide ion short of saturation; and the silver ions Nos. 5 and 6, located in corners, are short two! Since unsaturation can here be regarded as synonymous with reactivity, the increase of reactivity with decreasing dimensions becomes a logical consequence. In the range of colloidal dimensions the surface development and the importance of all energy located therein have become predominant. If comminution were to be continued, the dimensions of simple molecules, atoms, and so on, would be reached, where the expression "surface," as generally used, becomes meaningless. We are justified in calling colloid chemistry also the chemistry of surfaces and surface reactions. The regular chemist is primarily interested in the composition of the bulk phase of matter, the mineralogist in the crystal configurations of matter, the physicist in the physical properties of matter present in bulk form; but the colloid chemist is primarily concerned with the composition and reactivity of the surface layers of matter and the changes which these surface layers undergo. Let us be somewhat more specific about this difference among scientific interests.

A great many substances of colloidal dimensions, when they are suspended in water, owe their stability to electric charges located in their surfaces, which repel all particles of the same sign of charge. If these charges are neutralized by charges of opposite sign, the stability of the suspension is destroyed; the system precipitates. Systems of this kind are termed electrocratic colloids (Fig. 2). Other colloids, generally of organic origin, owe their stability to their great affinity to the liquid in which they are dispersed and are not affected by additions which neutralize surface charges. These are known as lyocratic colloids. If we coat an electrocratic colloid with a lyocratic one, we change the surface of the former. We have produced for all intents and purposes a colloidal dispersion of lyocratic properties. The dispersion will not be affected by electrolytes — we have "protected" the electrocratic colloid. This phenomenon is as important today to those engaged in the production of stable, finely comminuted suspensions such as paints, insecticide sprays, pharmaceutical preparations, fillers for paper, rubber latex, and in the production of ceramic slips, and so on, as it was centuries ago to the Chinese and Egyptians in the preparation of their inks and pigment colors.

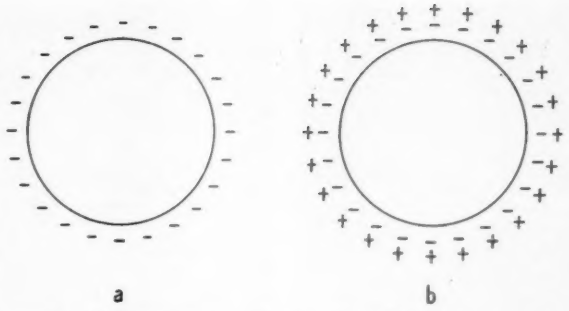


Fig. 2. (a) Negatively charged colloidal particle. (b) Discharged colloidal particle (simplified concept, schematic).

If we mix oil and water and agitate the mixture violently, we form what is known as an emulsion. But as soon as we stop agitating, the two liquids will again separate. If we add a soap, however, or form it in the system, the emulsion becomes stable. Stability occurs because the soap molecules line up in the surface of the oil droplets in an oriented fashion, one portion of each of the soap molecules lying in the water, the other portion being embedded in the oil; a new surface possessing repulsive energy has been formed (Fig. 3). From the purely analytical point of view, whether the emulsion is stable is of no importance; the emulsion is a system composed of oil and water. But knowledge of the mechanism underlying stable emulsification is not only important for the successful and economic production and application of emulsions but also essential when we are faced with the problem of destroying them. The manufacture and application of emulsions are becoming of increasing industrial importance in the production of noninflammable nitrocellulose preparations of low viscosity, paints and varnishes, plastics, insecticides, liquid food preparations, ointments, and so on. The destruction of emulsions is a vital problem in the refining of crude oil, in the purification of boiler feed water, and in numerous other similar activities. Of predominant scientific and industrial importance also is a

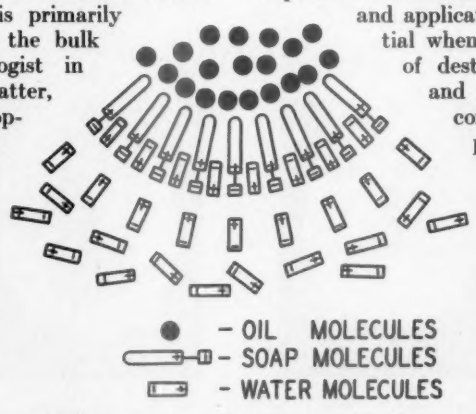


Fig. 3. Schematic stabilization of an oil-in-water emulsion by oriented soap molecules

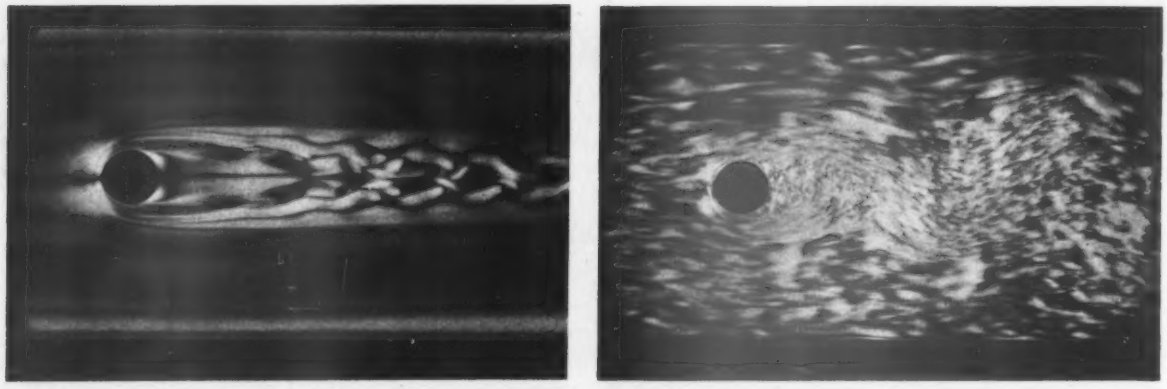


Fig. 4. These photographs of flow patterns of a dilute clay suspension between crossed polaroids were made in graduate research by D. R. Dewey, 2d, '40: (left) *slow flow;* (right) *rapid (turbulent) flow.*

better understanding of surface and interfacial tension and of wettability, which depends thereupon. Again the arrangement of molecules in the surface layer of colloidal thickness controls the phenomenon. If on the surface of a material which is not readily wetted by, let us say, water, a substance is adsorbed which, because of its molecular configuration, has affinity to both the material and water (see discussion on emulsions), the wettability is notably augmented. This increase is important in the dyeing of fibers and fabrics, in the coating of water-repelling surfaces, in impregnation, and in tanning. Interfacial tension has its great importance even in brewing and in medicine and biology. The use of specific wetting agents in sprays to overcome the danger of dust explosions in coal mines is finding enhanced interest and application.

The study of the mechanism causing colloidal dispersions to gel is constantly increasing in importance, for only by final solution of this question shall we be able to answer the most fundamental biological questions of cell life, cell division, and life quite generally. Many of the high-molecular organic compounds like natural and synthetic rubber can be classified as gels, and many others, like some of the modern plastics, present themselves as such in some step of their production or processing.

We could continue to enumerate many more colloidal phenomena and their scientific and industrial implications. The preceding discussion, however, has offered ample evidence that neither science in general nor most of the industries can any longer neglect the colloidal dimensions if they want to maintain progressive development. The M.I.T. is contributing its share toward an increase of knowledge in this comparatively new science and its manifold applications, both in regular courses and laboratory classes and in individual research. Though most of this work is carried out in the Department of Chemical Engineering, it would be impossible without the brilliant and constant co-operation of the departments of Chemistry, Physics, Civil and Sanitary Engineering, Electrical Engineering, and Metallurgy.

In broadening our knowledge and creating new concepts of the basis for the occurrence of colloidal phenomena, we are constantly finding new applications and at the same time aiding in the spadework which has to be done whenever a new and therefore largely empirical branch of natural science begins to take on definite shape and organization. The M.I.T. has made fundamental contributions to the theory of gelation, culminating in its research on the colloid chemistry of clays. These contributions have (*Concluded on page 182*)

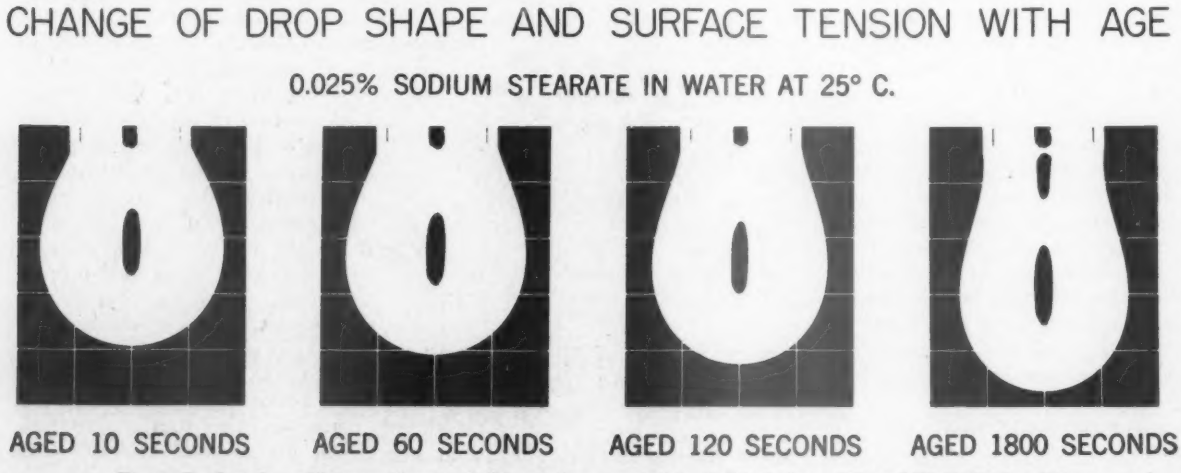

CHANGE OF DROP SHAPE AND SURFACE TENSION WITH AGE
0.025% SODIUM STEARATE IN WATER AT 25° C.
AGED 10 SECONDS
AGED 60 SECONDS
AGED 120 SECONDS
AGED 1800 SECONDS

Fig. 5. Pendant drop silhouettes photographed in graduate research by J. M. Andreas, '37, and W. B. Tucker, '37

From Logs to Riches

Canada's Newsprint Industry Profits from International Amity and Industrial Co-operation

By J. N. Stephenson

THE traditionally cordial economic and social relations existing between Canada and the United States are very largely based on the solid foundation of fair play in trade. A joint boundary commission, in businesslike discussion, amicably settles questions relating to the imaginary line where the two countries meet geographically; another joint commission regulates the proportions of water that are allowed to flow southward and northward from an international watershed; and a third deals with fishing in international waters. It is little wonder, then, that Canadians and Americans (meaning United States citizens) should have co-operated in the building of Canada's biggest manufacturing industry — the production of newsprint.

In Canada the first paper mill was started by Ware at St. Andrews East, near Montreal, in 1805. This mill made paper for the Montreal *Gazette*, and the chief business of the early mills was the manufacture of printing paper; all "fine" paper was imported from Europe — and some is still brought in.

The consumption of paper for printing was restricted by the cost and scarcity of raw material until the latter half of the 1860's, when groundwood was made in Canada and in Massachusetts. Sulphite pulp was introduced in both Canada and the United States in the 1880's. In *The Background and Economics of American Papermaking*, L. T. Stevenson shows the total paper production after 1880 to have begun a definite upward course and since 1890 to have struck a very rapid rate of increase which continued up to the well-known recent setbacks and is now again rising. The tremendous growth is due, of course, to the tapping of what was considered an inexhaustible reservoir of papermaking fiber — the forest. The biggest factor in this development was newsprint, a product consisting of wood fiber — at first roughly 70 to 75 per cent groundwood and 25 to 30 per cent sulphite pulp. Now the average ratio would be nearer 85 to 15 parts, respectively.

Wood is ground by pressing a stick sideways against a revolving grindstone. Sulphite pulp is made by reducing the wood to chips and, in a solution of calcium bisulphite under pressure, dissolving away from the cellulose fiber the various encrusting materials. The former is a mechanical process, consuming a great deal of power; the latter is a chemical process, involving careful control. Mills were naturally located where wood and water power were available. As the spruce — and balsam — became depleted, the industry migrated northward. Sometimes pulp mills were built to supply the paper mill with its raw materials. Wood began to be imported into the United States from Canada, and pulp mills were established in the Dominion.

Then came the movement for a reciprocity treaty in 1911. Some Canadian mills were making newsprint, and American publishers saw in the Dominion an important source of supply. The reciprocity agreement was not ratified by Canada, but the clause admitting to the United States free of duty "mechanical and chemical wood pulp and newsprint and other paper — valued at not more than four cents per pound" remained in force. This practically insured American newspapers plenty of cheap newsprint, of which Canada has sent them over three million tons in a single year.

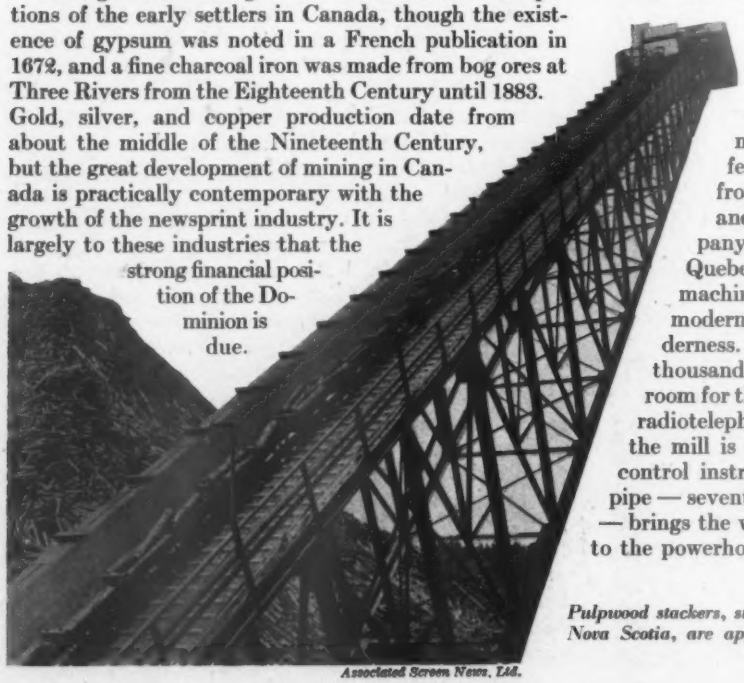
Here was Canada with abundant supplies of excellent pulpwood and with great rivers, rushing through the very midst of her woodlands, ready to transport wood to the mills and furnish the power to run them. And there was the American manufacturer with his ever growing market for paper and with men and money to help develop the natural resources of his friendly neighbor. It was the opportunity of a century for civil and electrical engineers to build mills and hydroelectric

power plants, roads and railroads; for forestry engineers — who were not much heeded — to operate woodlands; for mechanical engineers to design, build, and install machinery; for chemical engineers to devise and control processes; for the papermaker to enter the paradise of a big modern plant with up-to-the-minute equipment and make paper at heretofore unheard-of speeds; and, alas, it was also the chance of a lifetime for promoters to overdo a good thing, until eventually there was more capacity than publishers required. To my mind, this latter situation resulted partly from the impossibility in Canada of converting old mills to other uses, as had been done in the United States after new and better paper mills were built.

Favored by the requirement of the provincial governments, in which was vested the control of 90 per cent of Canada's forests, that this crown-land wood be manufactured in the Dominion, the industry grew. But there were free movement of men and money across the border and fair play on both sides. History has no finer chapter of international industrial development.

A close parallel to the development of the Canadian pulp and paper industry is that of the mining and metallurgical industry, which is founded on another of Canada's great natural resources — a tremendous reserve of minerals in extensive variety and of great commercial value. Each of these industries uses very large amounts of hydroelectric power. Each seems to embrace two categories: Lumbering corresponds to mining, in that both involve getting the natural resource away frnm nature and seem linked with the pioneering instinct of that young country; the manufacture of pulp and paper corresponds to the reduction of ores and recovery of metal values. The Dominion Bureau of Statistics gives us data (Table 1) for an interesting comparison of these two leading manufacturing industries in Canada in 1938.

Fishing and lumbering were doubtless the first occupations of the early settlers in Canada, though the existence of gypsum was noted in a French publication in 1672, and a fine charcoal iron was made from bog ores at Three Rivers from the Eighteenth Century until 1883. Gold, silver, and copper production date from about the middle of the Nineteenth Century, but the great development of mining in Canada is practically contemporary with the growth of the newsprint industry. It is largely to these industries that the strong financial position of the Dominion is due.



Associated Screen News, Ltd.

An important difference between the metallurgical and paper industries is that the former has been developed with comparatively little financial or engineering assistance from the United States. Canadians were responsible for the development of the pulp and paper industry, almost entirely, until well into the present century, but the building of their modern power plants and paper mills — at a cost of several hundred million dollars — has been done largely with American money and has involved some interesting engineering problems. It was natural that many of these jobs fell to experienced American engineers. Even for the mills where American men and money were not important factors, the market is predominantly in the United States. The four-machine newsprint mill built early in this century at Sault Ste. Marie by the Lake Superior Paper Company is believed to have been the first in Canada designed and constructed by an American engineer. George H. Mead, '00, was at that time vice-president of the company. This newsprint mill was the first, and until recently the only, sulphite plant to use pyrrhotite as the source of sulphur dioxide for the bisulphite cooking liquor.

When Canada began to develop her newsprint industry, she found it necessary to go either to England or to the United States to procure papermakers, for there were practically none within her own borders. Because of the speed of the machines she was using, as compared with that of the English, most of this skilled labor was obtained in the United States. It was largely this labor that formed the nucleus which developed later into the highly skilled paper-mill operatives now general in the industry and its allied branches. If a permanent staff of skilled laborers was to be built up, it was absolutely necessary that towns, and particularly school facilities, be developed adjacent to the mills. Probably the first "company town" in Canada was that at Grand' Mère on the St. Maurice River, built in the interests of the famous Laurentide Company, Ltd. Grand' Mère is still one of the show places of the province of Quebec, and its mill is one of the leading producers. It was the first newsprint mill to run paper machines regularly at more than a thousand feet a minute and has always been in the front rank in research and progress. Two years and a half ago, when the Ontario Paper Company, Ltd., put into operation at Baie Comeau, Quebec, the newest mill in Canada — a two-machine mill with complete power plant — a modern town was actually carved out of the wilderness. A large tract of forest was cleared and thousands of tons of rock were blasted to make room for the development. The town has a fine hotel, radiotelephone, and even a cold-storage plant, while the mill is equipped with the finest machinery and control instruments. The world's largest wood-stave pipe — seventeen feet in diameter and over a mile long — brings the water of the Outarde River from the dam to the powerhouse.

Pulpwood stackers, such as this one at the Mersey Paper Company in Nova Scotia, are approximately 120 feet high, travel on rails along the wood piles.

TABLE 1. COMPARISON OF CANADIAN PAPER AND METALLURGICAL INDUSTRIES

Industry	Capital Invested	Rank*	Salaries and Wages	Rank	Number of Employees	Rank	Gross Value of Production	Rank	Net Value of Production	Rank
Pulp and paper	$594,907,222	1	$42,619,311	1	30,943	2	$183,897,503	2	$89,034,186	1
Nonferrous metal smelting and refining†	184,337,126	2	19,549,963	8	12,788	17	287,295,733	1	87,091,374	2

* Among the forty chief industries of Canada
† The recovery of iron is relatively unimportant at present in Canada

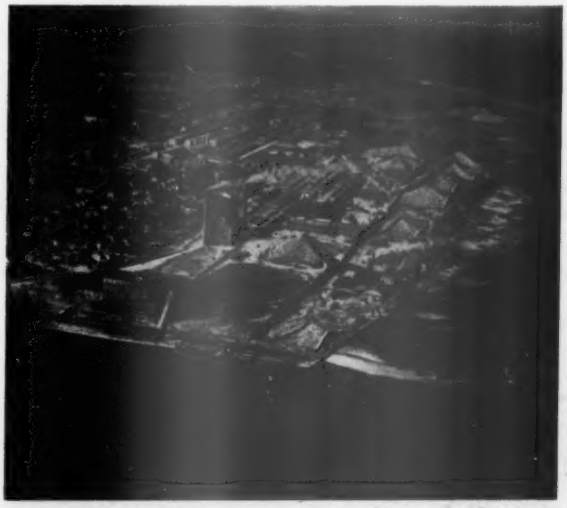
Advanced ideas and a continuous process of modernization have been characteristic of this company's operations since the establishment of its first paper mill near Niagara twenty-nine years ago by the Chicago *Tribune* — a newsworthy beginning for those days. It was the first mill in North America to use electric motors to drive mechanical pulp grinders. During the World War, when transportation became a major problem, a subsidiary concern was formed to operate boats to carry wood up the St. Lawrence to the mill and return with cargoes of grain or coal for Montreal delivery. On the completion of the Welland Canal, this water-borne traffic was extended to include the delivery of paper to Chicago, the boats carrying grain on their return trips.

Another instance of a Canadian newsprint mill in which an American newspaper publisher took a financial interest was the Spruce Falls Power and Paper Company, Ltd., at Kapuskasing, Ontario, the site of an alien internment camp during the World War. A sulphite pulp mill was first built there in 1918 by the Kimberly-Clark Corporation of Wisconsin. Later this concern was joined by the New York *Times* in the erection of a four-machine newsprint mill. The power comes principally from an interesting hydroelectric development at Smoky Falls, sixty miles down — though "up" in the geographical sense of being northward — the Mattagami River. This work required the building of a railroad which now serves to haul pulpwood to the mill, since the pulpwood on this part of the watershed cannot be floated up the river.

A big factor in the supply of newsprint to American publishers is the American-designed plant of the Anglo-Canadian Pulp and Paper Mills, Ltd., established in Quebec by the Rothermere interests of London. The engineering development that was largely responsible for making it possible to establish the four-machine mill on tidewater in the suburb of a large city was the high-tension transmission of electric power. In this mill the power to drive the machinery and operate the electric steam generators is brought about 140 miles at 165,000 volts. The building of the hydroelectric power plants from which this current comes provided epics of engineering skill. The century-old firm of Price Brothers and Company, Ltd., was assisted by Duke financing to develop the water power of the upper Saguenay River. The power plant at Ile Maligne, which is built into the dam that blocks the outlet of Lake St. John at the Grand Discharge, has a capacity of 540,000 horsepower. The by-pass for the stream during construction had to be blasted through the rocky island and was later closed only with considerable difficulty by use of a special cofferdam. A few miles downstream the Saguenay is really put to work and will ultimately produce another million horsepower. This development, at Chute-à-Caron, involved a particularly spectacular feat. An accurate contour of the rocky river bed was taken, and an exactly matching obelisk of concrete was erected on one bank of the river. So well was the engineering done that a perfect fit was accomplished when the obelisk was toppled into place, and a new chapter was written in the story of famous power plants.

The St. Maurice River is also a tremendous source of hydroelectric power, of which over a million horsepower have already been developed and are distributed by, or in co-operation with, the Shawinigan Water and Power Company. The important power sites were previously held by paper companies.

The outstanding example of an American paper concern developing Canadian resources on a large scale is the International Paper Company, incorporated in 1898. Some companies, like Laurentide and Abitibi, have built paper mills around established pulp mills, but International laid out from the ground up the world's biggest newsprint mill at Three Rivers. The plant was started in 1920 and built in two stages, each a fully integrated mill with four high-speed newsprint machines. Except for the steam required for processes and the bleeder turbo-generators on the paper machines, the whole mill is driven by electricity brought in at 60,000 volts. A remarkable feature of this mill is the tremendous increase in production over the original rating of the machines — from 640 to 850 tons a day — which has been accomplished by stepping up the speed and improving stock preparation and process control.



This newsprint mill — the world's largest — is that of the Canadian International Paper Company at Three Rivers, Quebec. Situated at the confluence of the St. Maurice and St. Lawrence, Three Rivers is also the focus of two other large paper organizations: St. Lawrence Paper Mills Company, Ltd., and Consolidated Paper Corporation, Ltd.

(Continued on page 180)

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

What Tech Men Do

THE experience records of Technology Alumni gathered by the Institute's Placement Bureau last year not only have been a very important aid in meeting the demand for exceptional men in industry and government but also have revealed the extraordinary range of professional activities of technically trained men.

A study of the 10,000 replies to a questionnaire sent to approximately 30,000 former students for whom the Alumni Association has addresses, reveals that Technology men occupy positions representing the performance of 130 distinct functions in 81 different fields of industry, business, and the professions. For example, a graduate might describe himself as the president or vice-president of a company, as a salesman, mechanical engineer, manager, or teacher. These categories of positions are classified as "functions," because the title of a position indicates the type of work performed. Function itself does not necessarily convey any information as to the branch of the industry or the profession concerned. These are designated as "fields." The distribution of graduates according to fields is, however, shown in Fig. 2. The limitation of this study to the functional aspect of the vocations is due to the large number of separate groups working in many fields. There are, for illustration, 22 classes of engineers and 23 large groups performing functions related to management, finance, sales, production, maintenance, construction, and other types of work in the sciences and professions. An array of 85 small groups remains, covering practically all the usual vocational activities, including legislators, journalists, clergymen, and even housewives. In addition, the engineering groups and many of the other larger categories include functional subdivisions, each of which represents a different kind of position. Thus, each group of engineers contains consulting engineers, chief engineers, those in charge of development, designers, draftsmen, estimators, research directors, project leaders, and research assistants. From the point of view of function alone, the composite picture of Technology Alumni is truly an intricate pattern on a very broad canvas.

Figure 1 indicates those functions in which at least 100 Alumni are engaged. The largest functional group, numbering 1,417, represents those Alumni who have risen to executive positions and indicates the achievement of leadership on the part of approximately one-seventh (13.8 per cent) of the total. About 1,100 other positions, at least partly executive in character, are reported as presidents, vice-presidents, chief engineers, and other titles indicating leadership. Still another group whose members are well toward the top of their vocations is made up of over 1,300 assistant chief engineers, resident chief engineers, project leaders, and others. This analysis would indicate that at least 3,800 Alumni, or 37 per cent of the total, have attained outstanding positions in functions related to management, to say nothing of those who have achieved eminence in technical and professional work in positions which are nonexecutive.

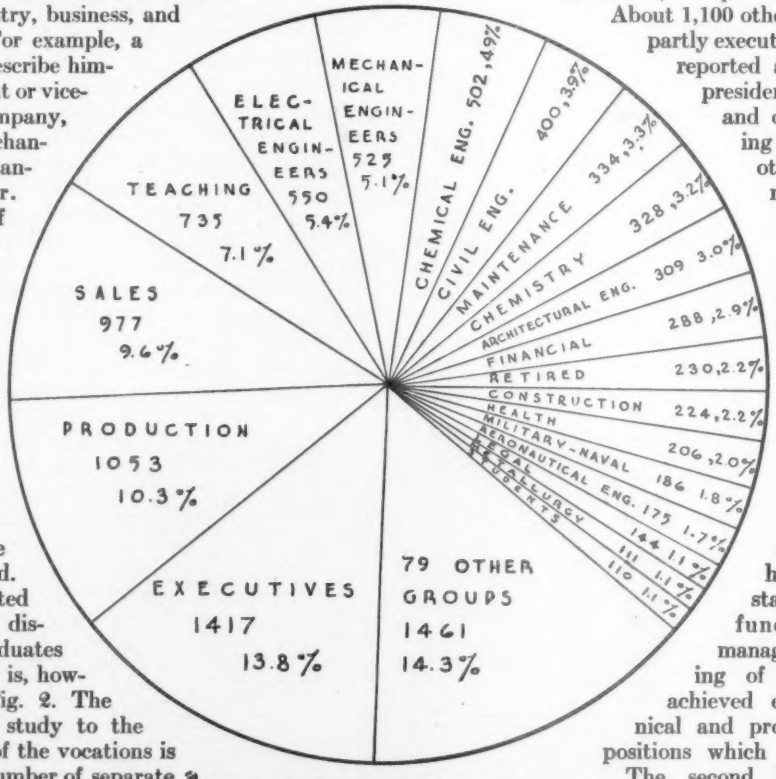


Fig. 1. Functions performed by Institute Alumni. Divisions of the graph represent those functions in which are engaged at least 100 of the 10,000 who responded in a recent survey.

The second largest functional group, designated "production," includes such categories as production and manufacturing, production control, process development, purchasing, and business engineering, and totals 1,053, or 10.3 per cent of all functions reported. The sales group is third in size with 977 Alumni, of whom only 253 took the Course in Business and Engineering Administration. The teaching profession is represented by 735 educators, comprising 7.1 per cent of the total.

In enumerating the functions reported by Alumni, we have thus far considered the four largest groups, which include 40 per cent of the Alumni. We now come to those who report specific engineering functions. The groups describing themselves as engineers include 21 branches of engineering with a total of 2,976, or 29 per cent of the graduates. Many of these groups, including government, business, valuation, hydraulic, traffic, illumination, combustion, acoustical, welding, and rate engineers, are too small to be shown in the graph of functions though as a whole they bulk fairly large. Seven-eighths of these 2,976 engineers are found in the six large groups, electrical, mechanical, chemical, civil, architectural, and aeronautical engineering.

In groups which vary in size between 25 and 49 are found such workers as personnel and labor relations men (48), insurance inspectors (47), service engineers (43), authors, editors, journalists, report writers, and translators (40), statisticians (38), technical directors (35), photographers (34), and clerks (31).

While functional groups of less than 25 members may be considered as relatively unimportant fragments of the total 10,000, they are significant in the aggregate because they show an impressive diversity of activities on the part of those who received their training primarily in engineering. Technology men are industrial designers, traffic engineers and managers, interior decorators, inventors, technicians, machinists, mechanics, and draftsmen. There are a group of factory trainers and another of office managers not classified as executives. An array of diverse groups includes Alumni performing the functions of actuary, agent, adjuster, examiner, and investigator. Specialized workers in science include mathematicians, anthropologists, archaeologists, astronomers, spectroscopists, and meteorologists. Librarians and curators are represented, as well as economists and social-service workers. A small group is engaged in nonlegal patent work. Two Alumni are legislators. Some graduates report the occupations of exporter and importer, merchant, farmer, and rancher. Nine Alumni have become clergymen. Information given in the replies also permits the analysis of engineering functions according to activities, as in Table 1.

Thus far, the data presented relate to given functions or categories of activities without reference to the industries, professions, or businesses in which the various functions are performed. Almost any single occupational function may be exercised in a few or in several different fields of endeavor. Thus executive functions are distributed among 72 fields; production functions among 65; sales, 64; financial, 53; mechanical engineering, 51; maintenance, 48; chemical engineering, 40; electrical engineering, 35; chemistry, 34; civil engineering, 23; construction, 16; and architectural engineering, 11.

Distribution of individual Alumni by fields is shown in Fig. 2. The largest field of work for Technology Alumni is the government, with a representation of 1,117 graduates (Federal, 717, and state, 400). Teaching occupies second place with 860, followed by utilities with 778. Business services, reported by 701, and construction, by 531, conclude the list of fields reported by more than 500 each, amounting to 4,649, or 46½ per cent of the total. Since the entire number of field replies is approximately 10,000, the percentage of any group may be read directly from the number represented. If, to the six groups mentioned, we add petroleum, 395; electrical equipment, 380; and machinery, 378, we have accounted for three-fifths (58 per cent) of the total in the nine largest groups. The remainder are distributed in many smaller groups, such as insurance, 224; airplanes, 192; food, 172; and finance, 167.

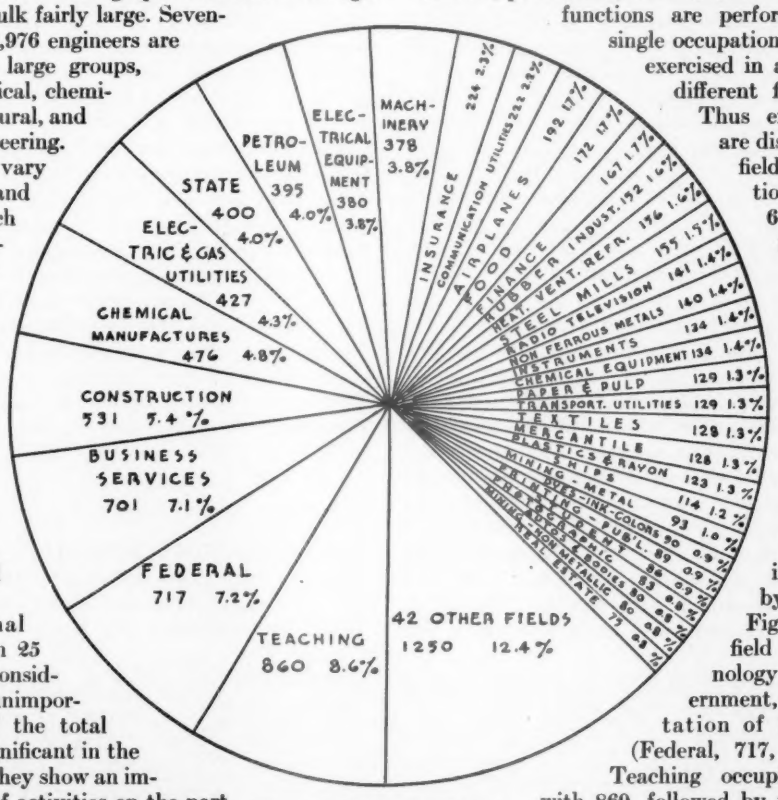


Fig. 2. Fields of activity in which at least 100 of the Alumni reporting are engaged

TABLE 1. ANALYSIS OF ENGINEERING FUNCTIONS

	Consulting Engineer	Chief Engineer	Assistant to Chief	Other Engineer	Director of Research	Other Research	Total
Electrical	42	58	225	129	13	85	552
Mechanical	27	90	180	142	28	58	525
Chemical	23	31	142	85	44	169	494
Civil	45	68	143	118	2	13	389
Architectural	194	29	24	62			309
Aeronautical	2	5	50	79	4	35	175
Metallurgical	6	4	25	16	9	51	111
Other	80	52	94	104	52	229	611
18 Groups of Engineers	419	337	883	735	152	640	3,166
	13%	11%	28%	23%	5%	20%	

No Mere Gesture in Shanghai

AS war continues to harass China, the Technology Club of Shanghai — only American university club in China which is holding regular meetings — is going ahead with substantial sponsorship of education for Chinese youth. Two years ago, a few Institute Alumni in China's great treaty port were instrumental in starting a school, known as the Shanghai Polytechnic Institute, to help meet the growing need for engineering education in the country. Statistics issued by the Ministry of Education had revealed that for 1939, students registered in engineering courses increased to 38.5 per cent of the total university enrollment — figures which suggested at once the need for training of men to fill the gap between professionally trained engineers and ordinary laborers. A great need for well-organized trade schools was obvious; from these, skilled mechanics and technicians might be secured. During its first year, the Shanghai Polytechnic Institute made a start in the right direction, with some forty students enrolled in evening classes.

At the beginning of 1940, the Technology Club of Shanghai commenced active participation in the undertaking. A committee investigated the possibilities of consistent aid to the enterprise, and efforts were got under way to stabilize curricula, to secure funds, to add to teaching equipment. Thorough study was made of the occupational needs which such a school is most likely to be called upon to fill, and the courses offered were organized with these needs in mind. When the present school year began in September, 1940, three fields were covered: automobile mechanics, electric servicing, and cotton textile engineering. The sum of $90,000 in Chinese currency had been raised, an amount sufficient to run the school for two years. A night school for factory workers is being run simultaneously in the same building, to supplement labor with various courses.

George H. Lynott, '15, is serving as president of the school, which is known as the China Institute of Industrial Training. William A. Adams, '08, is vice-president, and Hou-Kun Chow, '14, is vice-president and dean of the school. A report on educational activities made in November surveyed the work done thus far, pointing out that classroom instruction is maintained on strict routine, mechanical drawings and laboratory reports being checked and kept to schedule as carefully as they are at Technology. Syllabus committee meetings held at regular intervals during the fall focused efforts of the school on subjects common and fundamental to the special courses — subjects such as Chinese, business English, related mathematics, physics, chemistry, and mechanical drawing. Distribution of the various subjects through four semesters has been carefully planned.

Gathering together of adequate equipment for the machine shop and electrical laboratory, which are centers of teaching, has been going forward, and considerable amounts of apparatus have been donated. Twenty scholarships for qualified students in need of assistance have been provided.

A very practical "Tech in China" is thus being conducted under the auspices of the Technology Club of Shanghai, with the active aid of numerous Alumni.

Faculty Appointment

FRANCIS OTTO SCHMITT, Rebstock Professor of Zoology at Washington University, St. Louis, has been appointed professor of biology in charge of the Course in Biophysics and Biological Engineering at the

M.I.T. Photo

This efficiently lighted drafting room on the second floor of the new Sloan Laboratories is equipped with tack boards and shelves for plans and parts of engines.

Institute. Dr. Schmitt, who will join the staff of the Institute next summer, is distinguished and internationally recognized for his researches in biology, a field in which he has shown outstanding skill in utilizing the resources of associated branches of science. In the new art of biological engineering, he is expected to advance the present close co-operation between the Institute's Department of Biology and Public Health and its sister sciences, physics, chemistry, and electrical engineering.

This broad program of education and research in biological engineering, from which is developing a steadily expanding service to industry and medicine, is going forward under a grant of $200,000 from the Rockefeller Foundation.

Dr. Schmitt has utilized the x-ray, polarized light, spectroscopy, the electron microscope, and other tools and techniques of experimental physics in fundamental biological research. He is especially noted for his research on kidney function, conduction in heart muscle, tissue metabolism, chemistry and physiology of nerves, ultrasonic radiation, surface phenomena, mono- and multifilms, analysis of molecular ultrastructure of nerves and tissue cells by x-ray diffraction, polarized light, and light-reflection methods.

Born in St. Louis in 1903, Dr. Schmitt was educated at Washington University, which granted him the degree of bachelor of arts in 1924. Three years later he was awarded the doctorate of philosophy. From 1927 to 1929 he was National Research Council fellow in the department of chemistry at the University of California. During this period he also carried on advanced studies in the biochemistry department of University College, London, England, and at the Kaiser Wilhelm Institute in Berlin.

Appointed assistant professor of zoology at Washington University in 1929, he became associate professor in 1934, was advanced to the rank of full professor in 1938, and became head of the department of zoology in 1939. Dr. Schmitt is a member of the American Physiological Society, the Society of Experimental Biology and Medicine, Phi Beta Kappa, and Sigma Xi. He is married and has three children.

Whaling Collection

THE largest collection of whaling prints in existence, comprising about one thousand lithographs, engravings, water colors, and oils, has been presented to Technology by Allan Forbes, Jr. Additional prints have been contributed by the State Street Trust Company and by Allan Forbes, Sr., President of that bank, to supplement this notable collection.

These prints were gathered during some thirty years of discriminating search on the part of the senior Mr. Forbes, and include not only prints of whaling scenes from American, British, French, Dutch, Italian, Spanish, and Japanese sources but also maps, astronomical prints, cartoons, natural-history drawings, collections of pictures of Jonah and the whale and of Perseus and Andromeda, as well as bank notes in which the whale or whale ship appears. Notable are many original water-color portraits of ships by Benjamin Russell, constituting

Francis O. Schmitt

the largest existing group of paintings by this New Bedford artist. In its entirety, the collection covers completely the history and the many influences of a once great and important industry.

The collection will be housed in the Pratt School of Naval Architecture and Marine Engineering at Technology as one of the many outstanding exhibits in the Francis Russell Hart Nautical Museum. This museum has had for many years the Arthur H. Clark collection of marine prints, about 2,500 in number, covering principally the merchant-marine and naval fields. With the addition of the Forbes whaling collection, the Institute will become one of the most important repositories of marine pictures in this country. Interest in the whaling industry is already well established at Technology, for a special room in the Hart Museum for two years has been displaying the Henry P. Kendall whaling collection.

The installation of the Forbes collection will take place over a period of a year or so, and the first pictures to be put on display will be hung along the corridors and the main stairway of the Pratt Building. This use of pictures is in line with a long-range program of general museum development at the Institute, which aims to utilize for exhibits as much as is practicable of the four miles of corridor in the main group of buildings.

The nautical museum at Technology was recently renamed in honor of the late Francis Russell Hart, '89, a life member of the Corporation and for many years the Treasurer of the Institute. It was through Mr. Hart's interest that the museum received its initial development. Mr. Hart, who was a native of New Bedford, was internationally known as a collector of whaling prints, and a distinguished contributor to the literature on whaling.

Chips off the Block

THE Institute is particularly proud of the number of sons of Technology men who "come back to Tech" to prepare for careers in science, engineering, and architecture. The thirty-five sons who enrolled as freshmen this year are:

Son	*Father*
William G. Abbott, 3d	William G. Abbott, '06
Allen S. Arnold	Oscar M. Arnold, '13 (deceased)
Alvan D. Arsem	William C. Arsem, '01
Thomas S. Barrows	Ralph G. Barrows, '21
Gordon P. Caldwell	Walter E. Caldwell, '08
Richard L. Carter	H. Leston Carter, '08
Robert I. Clarke	Bruce A. Clarke, '16
Robert V. Coleman	Alfred V. Coleman, '15
Frederick D. DeBell	John M. DeBell, '17
Austin P. Dodge	Parker Dodge, '07
Kenneth M. Eberhard	Walter C. Eberhard, '14
Robert G. Fisher	Dana H. Fisher, '02
Roger M. Freeman, Jr.	Roger M. Freeman, '13 (deceased)
John B. Gardner	Hartley B. Gardner, '17
Richard B. Gore	John Gore, '16
Dean B. Harrington	Elliott D. Harrington, '08
Peter S. Hopkins	Paul S. Hopkins, '10
James T. Lawson	Charles J. Lawson, '20
Carl Lindemann, Jr.	Carl Lindemann, '12
Richard C. Maconi	G. Vincent Maconi, '15
Paul G. Nelson	Albert P. Nelson, '13
Robert D. Peck	Harry D. Peck, '13
William W. Pugh	Achilles H. Pugh, '97
George M. Repetti	George W. Repetti, '16
John A. Rockett	Francis H. Rockett, '17
James S. Ruoff	Chauncey F. Ruoff, '14 (deceased)
William B. Scott	Stanley L. Scott, '21
Gardner H. Sloan	Vernon G. Sloan, '12 (deceased)
Carl R. Soderberg, Jr.	C. Richard Soderberg, '20
Thornton Stearns	Albert T. Stearns, '14
Caleb S. Taft	Edgar W. Taft, '13
Richard R. Wareham	Charles M. Wareham, '16
Stanley W. Warshaw	Nathaniel Warshaw, '16
James B. Weaver, 2d	Eastman A. Weaver, '15
Edward H. Williams, 3d	Edward H. Williams, '16

Corporation Election

CHARLES E. SPENCER, JR., President of the First National Bank of Boston, was elected a special term member of the Corporation at its meeting on January 8. He will serve for five years.

A native of New Brunswick, N.J., Mr. Spencer was educated at Rutgers Preparatory School. Between 1900 and 1907 he was successively associated with the National Bank of New Jersey, the National Bank of Commerce in New York, the National Bank of Commerce of Kansas City, and the Trust Company of America in New York. In 1907 he was appointed assistant treasurer and later advanced to the post of treasurer of the Colonial Trust Company of Waterbury, Conn. From 1918 to 1920 he was deputy governor of the Federal Reserve Bank of Boston, leaving that position to become vice-president of the First National Bank, of which he was elected president in 1938.

A director of the First of Boston International Corporation in New York, Mr. Spencer is a trustee of the Warren Institution for Savings in Boston and the American Optical Company, and a director of the Boston Tidewater Terminal, Inc., the United-Carr Fastener Corporation, the French American Banking Corporation, Arthur D. Little, Inc., and other companies. He is a member of the Algonquin Club of Boston, The Country Club of Brookline, the Union League Club of New York, and the Kittansett Club of Marion, Mass.

Pirie MacDonald

Charles E. Spencer, Jr.

Rogers Awards

WILLIAM BARTON ROGERS awards of $300, which are given annually in memory of the founder and first President of the Institute in recognition of high scholarship, character, and leadership in student affairs, have been presented for 1940 to six Technology seniors: William R. Ahrendt of Westfield, N.J.; Eugene E. DuP. Crawford of Wilmington, Del.; William M. Folberth, Jr., and Lawrence C. Turnock, Jr., both of Cleveland, Ohio; Joseph H. Myers of Evanston, Ill.; and Donald D. Scarff of Winnetka, Ill.

Presentation was made by President Compton before the Faculty Committee on Undergraduate Scholarships, of which Dean H. E. Lobdell, '17, is chairman, and the Heads of the students' Departments.

Augmented Analyzer

EXTENDED 25 per cent in equipment and thus expanded some 40 per cent in scope, the M.I.T. network analyzer during the past few months has proved better than ever able to assist electrical engi-

neers in settling power-system problems, as well as to give students of power engineering a realistic comprehension of the nature of these problems through actual experience in solving them. An entire new fifth section was added to the analyzer last summer, and important changes were made in the proportion of the units added, so that more effective use can be made of the device as a whole. These changes and additions, plus the high-speed precise centralized metering system developed and installed three years ago, plus increase in the number of generator units (sixteen can now be represented) have brought the analyzer up to the highest of present-day standards.

The Institute's analyzer is the only apparatus of its kind maintained by an organization other than a public utility or electrical manufacturing company. Needs disclosed by problems presented by industrial users of the machine led to the addition of the new unit, which was directed in its design, construction, and installation by George B. Hoadley, '32, while he was instructor in electrical engineering at the Institute. Last fall Dr. Hoadley joined the faculty of the Polytechnic Institute of Brooklyn as assistant professor and has been succeeded in supervision of the analyzer by Arthur E. Fitzgerald, '31, instructor in electrical engineering.

Designed to investigate electrical power-system problems arising in additions to existing systems, in interconnecting systems, and in routine or emergency operation, the network analyzer is an arrangement of power sources, resistances, reactances, and other elements which permits compact reproduction of the significant electrical characteristics for problems of these types. It may be considered an electrical scale model, in which 100 watts represents, for example, 100 million watts, and in which networks that may actually extend over several states are reduced to the dimensions of an ordinary room. Among devices of the kind, that at Technology is the foremost in the number of generating stations which it can represent and in the precision of the metering with which it is equipped. In operation, the analyzer gives all readings at a central desk, so that the operator is able in effect to travel hundreds of miles from station to station of his system without ever leaving his chair.

As originally constructed twelve years ago, the analyzer comprised four large steel-framed sections housing the resistor and reactor units, the capacitors, and the other devices necessary to reproduce in miniature the significant electrical variables involved in a system problem. Phase-shifting transformers are used to represent generating stations. Provision for all kinds of interconnection is made. The expansion of the analyzer last summer consisted principally in addition of an entire new section. This increase by one-quarter in the physical apparatus involved meant more than a one-quarter increase in effectiveness, however, because the size distribution of units was so amended as to bring about improvement of one-third or more therein.

Three years ago, advancement in metering technique greatly increased the speed of operation of the analyzer. The speed of an instrument is, of course, dependent upon the amount of power which it consumes. But the insertion of metering equipment into the model network must not disturb the system (*Continued on page 181*)

Not a belated snowfall, but the lawns of the Great Court as infrared film records them

L. Rosenblum, '42

THE UNEMPLOYED

(*Concluded from page 151*)

have milk. The rent allowance is seldom sufficient, for if adolescent children of opposite sexes are not to share the same bed — to say nothing of not occupying the same room — inroads must be made on the food budget. There is enough clothing to fight the elements; there is not enough to enable visits to friends or church attendance. Nor is there money for the dentist, the barber, and the druggist, not to mention money for a movie or a glass of beer. Worse still, men on relief have lost confidence in themselves: After constant rebuffs in their search for employment they now recognize that industry will not hire men in patched garments, without tools, in arrears to the union. They feel that private industry does not want them, a fact which does not mean that they do not want jobs in private industry.

Today, they are broken men, with their family relations severely strained. Nothing would be farther from the truth, however, than to think of these men and their families as having been in such poor straits always. True, the men came from relatively poor homes and had had relatively little education, but they were able, during the days when the economy prospered, to gain a secure niche and to support not only themselves but also their wives and children. The wives, who for the most part came from families in poor circumstances, seldom had had more than an elementary education, and not always that. But the handicaps did not prevent the women from securing employment, which enabled them to support themselves and frequently contribute to the support of indigent relatives. Frequently after marriage, always after the birth of a child, the wife ceased earning, for the running of a home was a full-time job. The man earned and the woman managed, and together they enjoyed a normal family life like that of millions of other Americans. Seldom did the man receive large wages, but his earnings were sufficient to permit him to discharge his responsibilities without assistance from private or public agencies. Such men were independent folk who worked during the week, went to church on Sunday mornings, relaxed by visiting friends and relatives, and occasionally left town on a hot summer's day. In short, they were normal people and theirs were normal families.

When the men lost jobs they had held for many years — a few men had actually worked for the same firm for a decade or two — they believed that their unemployment would be temporary. They sought work avidly and for a long time were unable to accept the fact that industry no longer had a place for them. With wages a thing of the past, savings accounts were drawn upon to keep the families in food; when savings gave out, insurance policies were cashed; finally, when debts could no longer be avoided, relatives and tradespeople were asked to assist. After these resources were exhausted, public assistance alone remained, but the pride of these people was such that many refused to apply, and the plight of more than one starving family was called to the attention of the department of welfare by a friendly neighbor or a sympathetic policeman. Loss of work, of savings, of friends, of self-respect, has marked the men and their families so badly that it is difficult to realize that not many years ago they were neither dependent nor demoralized.

The American public, which has been much concerned about the size of the annual appropriations for relief and about the scale of allowances for the unemployed, has failed to appreciate the extreme wastefulness of unemployment. When a man of forty loses his job and fails to secure another, the twenty or more years of working life that are in him are lost to society. While employed, such a man contributed approximately $1,500 annually by his labor; while he is unemployed, society must pay him approximately $700 a year to keep him and his family alive. In twenty years his unemployment will have cost $16,000. But the total cost to society may prove much greater: Severe deprivation at home can injure a child permanently — physically, mentally, morally — with the result that the state may be forced in later years to maintain him in a tuberculosis sanatorium, a mental hospital, or a prison. Good accounting assesses costs where they belong. Hence the expenditures for state hospitals and prisons should be assessed in part against homes where work for the father is only a remembrance of things past and no longer an expectation for the future.

The costs may become so large that they can no longer be expressed in monetary terms. When older men are thrown out of work and younger men are not afforded opportunities to work, the entire social structure is undermined. Many were the factors that gave Hitler his chance, but none was more important than the economic disenfranchisement of a large part of the German populace. Without work and without hope, the disenfranchised came to despise prevailing institutions and, when afforded leadership, they destroyed those institutions. As long as the majority cherishes its way of life, it must not fear expenditures aimed at preventing the growth of the economically disenfranchised, for if the latter multiply, nothing remains secure. In the United States today are third-generation "reliefers." Children are being born into families whose fathers have never worked and whose grandfathers have been unemployed for more than a decade.

Unemployment is, however, largely a problem that has arisen in the last decade, and it is scarcely surprising that the American public has erred seriously in grappling with it. The new is always difficult to understand and to control. But all was not error. The concept of work relief was fundamentally sound, though the emphasis was too much on relief, too little on work. Nor were all mistakes those of government. Industry and the community at large were likewise at fault, industry being prejudiced against hiring men previously on relief, and the community's uninterest speeding demoralization.

During the coming months, the more employable men who are now in receipt of public assistance will doubtless obtain positions in private industry. If community resources, public and private alike, are utilized properly, the number employed can be substantially increased. The state employment agency must seek jobs for these men; the employer must overcome his prejudice against hiring them; the social agency must assist in rehabilitation.

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BEHR-MANNING DIVISION, TROY, N. Y. (ABRASIVE PAPER AND CLOTH)

THE TREND OF AFFAIRS

(*Continued from page 149*)

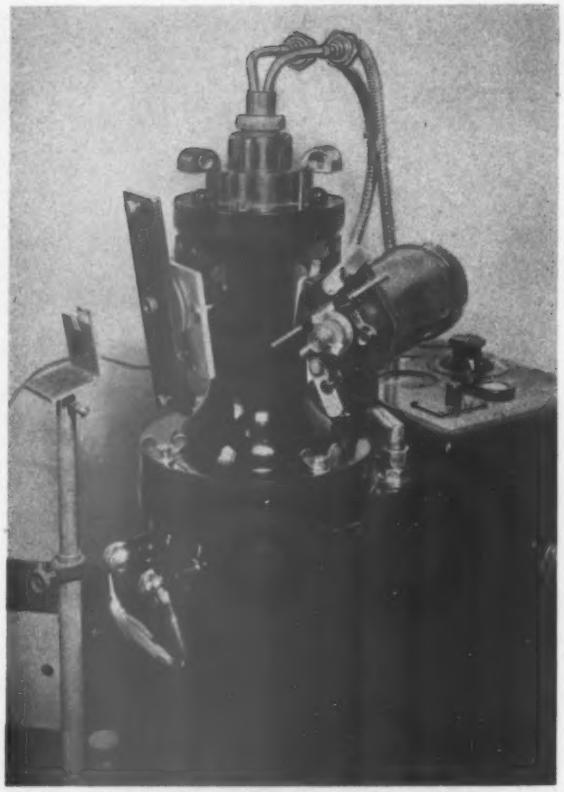
is used in the manufacture of wooden door handles and other forms of "hardware." ¶ About five million pounds of tung oil are expected to be produced from the 1940 bumper crop yielded by plantations of tung trees in the southern United States. The American tung oil industry, now thirty-five years old, will thus supply about one-twentieth of American consumption of this, one of the most important of the drying oils. The price of the oil from China — traditional world source of the material — has been about twenty-five cents a pound for the past year. American production has often commanded a premium of a cent or two over that figure because of superiority in lightness of color and in general chemical characteristics.

Inside the Metal

FABRICATION — by welding, for instance — not only builds metal members into structures of various sorts but also does hidden things to the internal structure of the metal members themselves. Weld steel plates together according to a certain plan, and a tank or a bridge girder or a ship's deck results; within the plates, meanwhile, an unseen patterning of strains is produced as the welds are made. Some of these strains are great enough to produce plastic flow. Detection of their presence and their extent may be of profound importance to the fabricator, for ability to reckon with them and allow for them can contribute powerfully to making structures of longer life and greater reliability.

Strain, whether plastic or elastic, means essentially that the spaces separating the atoms of the metal have been altered by the application of load and that hence the metal has been deformed. Its size has been changed — in microscopic terms, of course, but nonetheless changed. If the strain is a plastic one, actual gliding action of the crystals of the metal has occurred, and a new positioning of the atoms has been established, with the result that removal of the load does not produce resumption of original dimensions by the metal. An elastic strain, on the other hand, is an alteration of interatomic distances which lasts only as long as the local stresses continue; removal of these stresses permits the atomic pattern to return to normal. Though the atoms have been sprung farther apart or pushed nearer together, depending upon the type of loading, they have not been subjected to forces strong enough to break their original bonding and make them actually glide into new relative positions.

When loading produces a combination of plastic and elastic strains within a metal, ability to distinguish between them is important to the designer. Because of the permanent distortions which the loading may have produced, elastic stresses may be locked up inside the metal even after the external load is removed. If a new load is applied, they will co-operate with the new stresses which it imposes, so that the limit of strength of the material may be approached.



X-ray diffraction instrument for measuring internal stresses in metals. The specimen under test is mounted on the stand at the left. X-rays impinging on it through the orifice at the left of the central x-ray tube are diffracted through the slots in the vertical film holder, to register on the film as lines indicating the atomic structure of the specimen.

Determination of strains by conventional extensometer methods is handicapped for the fabricator by the fact that strains do not appear until load has been applied — until, in other words, the material has been built into a structure. To determine strains by the extensometer, it is necessary to remove the load, that is, dismantle the structure. This necessity grows out of the fact that the extensometer method requires two measurements, one without load and one under load.

Implicit in this story thus far are the reasons why demonstration of the practicability of a more effective method of stress measurement is welcome. That demonstration has been under way in the Institute's Department of Metallurgy during the past year, through the investigation and development of an x-ray diffraction method of measurement. John T. Norton, '18, Associate Professor of the Physics of Metals, building on the work of German investigators, has checked the precision of the diffraction scheme, has applied it to the measurement of stresses near welded joints, and has found it to give results whose accuracy increases as the stresses measured are greater.

If gauge marks are made on the surface of an unstressed plate and load is then applied, change in the distance between the gauge (*Concluded on page 174*)

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Each entry remains the property of the sender.

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Winners will be chosen for the inventions, devices, improvements or ideas which, in the Jury's opinion, contribute most to speeding up America's Defense Program.

It is desired that all entries be placed at the command of the Defense Advisory Council at Washington, D. C., subject to the entrant's own written consent.

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Entries close on midnight, April 30th, 1941.

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★ ★ ★ ★ ★

THE TREND OF AFFAIRS

(*Concluded from page 172*)

marks after the removal of load shows that plastic flow has occurred; the plate is longer or shorter than it was before application of the stress. If the stress is merely elastic, however, the relative position of the gauge marks is unchanged after removal of load, for the plate has returned to normal dimension. Hence, to determine elastic stress, it is necessary to make measurements while the plate is under load and while advantage can be taken of the temporary shifting of interatomic distances which has been described. The x-ray diffraction method does just this task, detects elastic stresses without any necessity for the dismantling of the structure in question, and detects elastic stresses only.

The diffraction technique relies upon the fact that different substances diffract x-rays at different angles, depending upon the atomic structure of the substance. The normal interatomic distances of materials being known, deviations from them can be detected by deviations in diffraction patterns, from which in turn the magnitude and direction of stresses can be calculated. In the making of diffraction measurements, a spot of gold powder is placed on the specimen being examined for stresses. The gold is without stress; hence its atoms diffract incident x-rays at a known angle, so that the diffracted rays give a register line on the photographic film which they strike after being diffracted, or bounced back, from the gold. Some rays, however, will go through the gold powder to the metal of the specimen and will bounce back at an angle depending upon the atomic structure of the metal in question. The line which they give on the film should hence be at a predictable distance from the gold line — the distance being determined by the difference between the angles of diffraction of normal gold and normal other metal. If the other metal is under elastic internal stress, however, the telltale distance will be different from the normal, the difference depending upon the extent to which normal distances between the atoms of the material have been altered by the stresses.

Close measurement of the reference gold line and the specimen metal line on the photographic record is hence of much importance in the development of the diffraction technique. It may be made difficult by fuzzy lines, such as are recorded by diffraction from certain alloy steels. But by careful check, having the same records gauged by several researchers, Professor Norton finds that the error remains constant, however great the stresses studied, and this constant error is not very great to begin with.

In a steel plate with a weld running along one edge, the diffraction technique has been used by Professor Norton to show the existence of a complicated distribution of stresses. Immediately under the weld the stresses closely approach the elastic limit of the material, suggesting that actual plastic flow has occurred. In the rest of the plate, compression and tension are readily located. Cutting off the weld and testing the specimen anew, Professor Norton found that stress patterns remained unchanged in the area nearest to where the weld had been — plastic flow, as suggested, had taken place — and that the stress patterns in the rest of the plate diminished. When the strip along the once welded edge was cut away and the area where deformation had occurred was thus removed, the elastic stresses in the remainder of the material were eliminated.

Next step in the investigation of this technique will be to weld a structure, setting up in it elastic stresses reaching the elastic limit of the material; then to load it externally; and, finally, to take the resultant stress patterns in order to ascertain whether plastic flow occurs to relieve the stresses set up by the external load. Thus may be supplied answer to the question whether loading, as in making use of a welded pressure vessel, relieves the local stresses originally imposed upon the material of the vessel when it was welded together. Such relief would result from the infinitesimal flow of the atoms of the metal as it changed its size in order to accommodate itself to the stresses. If such flow occurs, a more nearly uniform distribution of stresses results.

RENAISSANCE METALLURGY

(*Continued from page 157*)

mold directly, including runners and gates. Biringuccio describes molds made of clay in several layers bound together and containing as many as twelve hundred pieces. Fine works, such as medallions, were usually cast in a molding composition of ashes, iron scale, burned clay, or other refractory material, bonded with a sodium silicate solution made by strongly heating salt in a clay pot. For other work clay was used, mixed with sand to minimize shrinkage and with various common organic materials to give it body (and B.O.!), but it was always thoroughly baked before casting. Leonardo da Vinci mentions the use of green sand molds, but Cellini says only some Paris sand can be so used. Biringuccio made a mold, to be cast without drying, from burned sand and ashes bonded with flour and urine or wine, but says it is an art that many desire but few practice. Die-casting was well established in the type-founder's shop, whose product had to be clean and accurately made to size. The pewterer used stone or metal molds.

The shaping of articles in dies was not unknown. Coins represent the earliest attempt at quantity production by the use of dies, but the necessity for repeated hammer blows must have made it a laborious process. Already in the Sixteenth Century the wedge and the screw press were being employed in mints, and blanks were sometimes cut by the use of hollow punches from flat strip (at first drawn through dies but later rolled), thus minimizing the work of the weight adjusters. These improvements were known to Leonardo da Vinci and may have been his inventions. The use of mating dies to shape an article from sheet metal (the basis of most modern ways of making small objects in quantity) generally presupposes the use of an accurately guided press of some kind. We find, however, in one of Amman's woodcuts (1568) a regular cupping operation with punch and die being used to make thimbles from well-annealed brass strip, and this process was doubtless used for other products too. (*Continued on page 176*)

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der Metall zů nutz mit groſſem fleiß
zůſamen gebracht.

Title page of the Probierbuchlein *(1534 edition). This, the first printed book dealing with metals, contains a brief account of fire assaying and refining methods for gold and silver, and describes systems of assay weights for various localities.*

RENAISSANCE METALLURGY

(Continued from page 174)

Development in the field of alloys was slow. With the exception of cast iron, the only alloys in extensive use even as late as 1800 had been known and employed by the Romans—brasses, bronzes, various coinage and jewelry alloys, speculum metal, solders, steel, wrought iron, copper, and pewter. The old alloys served the purpose of the craftsman well enough, and engineering had not yet reached the point where further advance was dependent on the development of newer materials. Physical data on metals and alloys, moreover, were accumulated but slowly. Density was studied very early and was commonly determined in studies of alloys, but some Seventeenth Century attempts to ascertain tensile strength were followed by only sporadic imitations. It was not until publication of the classic work of Achard in 1788 (unfortunately but little known to contemporaries) that a really systematic attempt was made to study how strength, hardness, malleability, and corrosion resistance vary with composition.

Soldering was done with various alloys whose use indicates a knowledge of the general form of the melting-point diagram. Gold was soldered with gold-copper alloys, which were sometimes produced *in situ* by combination of the gold surface with copper reduced by the soldering flame from finely divided copper oxide or carbonate. Silver was soldered with silver-copper alloys, copper with silver-copper-zinc or lead-tin. When iron could not be hammer-welded, it was brazed or soldered with silver, copper, or silver-copper-zinc alloys. Powdered metals were made mechanically or, as in the case of gold and silver, by powdering a brittle amalgam and driving off the mercury with sulphur and heat. Bimetals of copper coated with silver or of silver with gold were commonly made for both fraudulent and legitimate purposes.

The casting of bells and the casting of guns are old arts calling forth the greatest efforts of the metallurgist. The two techniques are almost identical: Both involve the production of a reinforced clay core, a wax or clay pattern on this, and an outer jacket, all being built up on a simple lathe with strickles. Cannon were cast in bronze of about 10 per cent tin, while bell metal contained 19 to 21 per cent. A large feeding head was used on the cannon, but bells seem to have been cast without the heads, probably because unsoundness at the crown is not particularly harmful. Biringuccio gives a scale showing the actual thickness of the rim for bells of various weights and gives full details for design of them. He has drawings of a number of ingenious bearings to lighten the task of the bell ringer.

Methods of heat production are always of prime concern to the metallurgist. Although coal was known and used, wood and charcoal were the principal fuels in the Sixteenth Century. Reverberatory, wind, and blast furnaces were used for smelting ores and melting metals. Small charges were melted in crucibles in the forge fire of the smithy. The blasts for the forge and the larger furnaces were provided by bellows, very elaborate contraptions being used to operate them by water power.

The reverberatory furnace for melting metals is first described by Biringuccio. It was an outgrowth perhaps of the glassmaker's furnace or perhaps of the cupellation furnace in which the wood fuel and the metal to be melted and oxidized were in contact under a large dome or reverberator. Chimney stacks to create drafts without mechanical aid were rarely used, and even the wind furnaces depended only on their own small height to produce a natural draft.

The nonferrous metals were usually smelted in blast furnaces measuring some two feet square and six feet high, built against a wall backed by the bellows machine. Different kinds of ore were usually mixed together for smelting in order to provide a more fusible slag and to aid in the collection of metal values. The copper-lead liquation cakes produced by the blast furnaces were given a prolonged gentle heating to allow the lead to run off, leaving a spongy mass of copper.

The lead (carrying most of the precious metals present in the ore) was cupeled to give an auriferous silver from which gold was recovered by parting with nitric acid or with sulphur or antimony sulphide. The separation of all the metals in the ore was complete when the litharge from the cupel and the silver-laden materials from parting had been reduced back to the metallic state. The copper was refined by an oxidation and reduction cycle in a glorified smith's hearth with a basin and was prepared for the market as rosette copper by the pouring of water on the surface of the molten bath to form thin crusts of solid metal which were lifted off one by one. Metallic zinc had been practically unknown before 1685 except as a sporadic furnace condensate. Until the Nine-

teenth Century, brass was made directly from copper, calamine, and charcoal contained in clusters of small pots in deep conical furnaces built below the casting floor and dependent upon their own height rather than upon a stack to provide draft. Bronze was melted in crucible furnaces of various kinds, or in large ladles which served to contain the metal and charcoal — the latter urged by bellows. A ring of stones built around the ladle lip retained a greater quantity of fire. A charge too large to be carried was melted in a reverberatory furnace or in a veritable cupola with a receiver to hold the liquid metal at the bottom and a shaft to hold the metal and charcoal above the tuyère line. A taphole at the bottom of either furnace and a series of channels conveyed the metal to the molds, which were buried in pits.

Wind furnaces for crucible assays were sometimes aided by the blast from an aeolipile, a copper boiler providing a fine jet of steam, which carried air into a small opening below the fire bars. Muffle furnaces operated on their own draft. The muffles were bottomless and rested on the bottom of the furnace, heat being applied only from sides and top. The assayer's cupels, crucibles, and scorifiers and the technique of using them, including the fluxes, as described by Sixteenth Century authors, were very much the same as the implements and technique which are used by the fire assayer of today. The heat treatment of metals was a simple process and required simple furnaces. The wiredrawer and coppersmith used an open pile of charcoal on a grate, sometimes aided by bellows, for annealing. Delicate soldering was done in muffle furnaces or sometimes under little arches made of the charcoal itself. The smith heated steel for hardening at the forge fire and quenched it directly to the final hardness without any drawing or tempering operation. This change in practice is reflected in the confusion of terminology that to this day makes the layman think of tempered steel as being hardest, as at one time it was.

Incidentally, the realization that interrupted slow quenches were given makes more reasonable the employment of the various curious quenching liquids and nostrums that it has been common to scoff at on the assumption that rapid complete quenching was sought. While insisting on the virtues of the urine of a red-headed boy or a fern-fed goat in preference to any other may be making too fine a distinction, it seems likely that a more controllable quench could be given by a solution containing organic matter, and the temper colors could be seen more readily because less oxidation would occur at high temperatures. An interrupted quench gives far tougher steel than does a full quench and draw, though it needs better control. The best product of the ancient armorer, though only occasionally achieved, may actually have been better than our modern heat-treated steels until the austempering process, that triumph of modern metallurgical research, duplicated it.

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TECHNICAL PROGRESS IN AVIATION

(*Continued from page 154*)

obtainable from the exhaust. The degree of interest which commercial air lines will take in jet propulsion will depend on whether their future requirements include much higher speeds of flight.

Technical progress of another kind is based on research in aerodynamics. With improved wing sections, the ratio of lift to resistance to forward motion has been notably increased in recent years. This increase should make for higher speeds with the same power, but the so-called high-speed wings are not good weight carriers and would entail too high a landing speed to be practical for commercial aviation. By means of slots and trailing edge flaps, it is now possible, when approaching a landing, for the wing to be converted temporarily to a high-lift type. Since improvement of high-lift devices of this sort is of great importance to bombers as well as to commercial planes, military pressure may be expected to speed it.

With higher wing loading, the length of run at take-off requires large airports; hence the considerable enlargement of our American airports, which will be part of the defense program, will aid the extension of our already rapidly expanding civil air-transport industry.

Even the so-called experts have been badly misled as to the importance of one feature of technical progress. I refer to questions about the ability of the American type of radial air-cooled engines now universally used by our air lines. Since European engines are liquid cooled and are used in high-speed pursuit machines, like the British Spitfire and the German Messerschmitt, the idea that this country cannot build high-speed fighting airplanes until it has liquid-cooled engines of the European type has been widely accepted. And because certain stripped German airplanes broke the world's speed records twice in 1939 — a Heinkel in March at 464 miles an hour and a Messerschmitt in April at 469 miles officially and 481.4 unofficially — the momentary speeds developed have been accepted as inherent in the liquid-cooled engine which was used. This is an entirely false inference.

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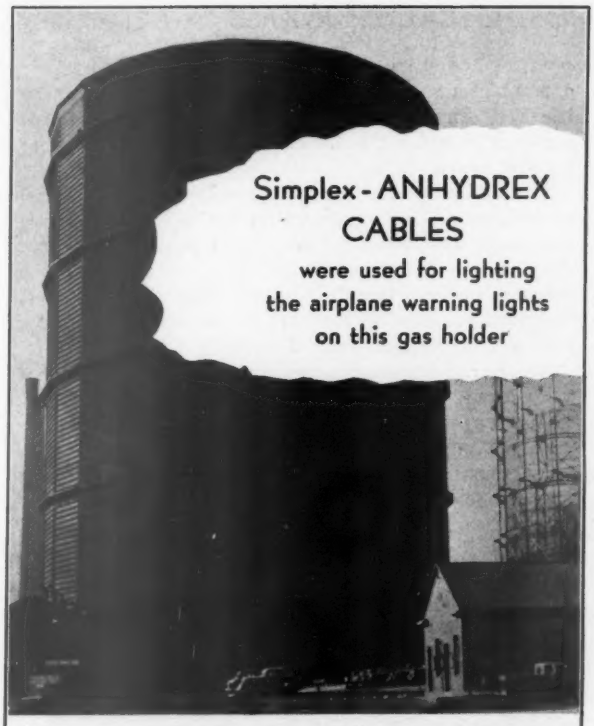
THE TECHNOLOGY REVIEW
M.I.T., CAMBRIDGE, MASS.

At the time that the Germans were claiming the world's speed record, American planes equipped with American air-cooled engines of similar rated power output were making in normal flight a high speed of about 330 miles an hour, while British planes with liquid-cooled engines of the same power output were credited with 360 or more miles an hour. The case for the liquid-cooled engine seemed to be very convincing. Yet it was based on a false conception of the aerodynamics of the matter. There was also an element of propaganda in it.

The test of war has shown that the German fighting planes have a real speed of about 350 miles an hour and that their British opposites make the same speed or a little more. In the meantime, progressive improvement in the installation of the American air-cooled engines has raised the speed of our fighter planes.

The National Advisory Committee for Aeronautics, in its Langley Field wind tunnel, has developed means of streamlining the American radial air-cooled engine by ducting and cowling, so that its drag can be made as low as that of the best liquid-cooled engine installation. Thus recent technical progress has enabled American airplane builders to demonstrate airplanes with larger air-cooled engines at speeds exceeding 400 miles an hour. There now appears to be nothing to choose, as to speed, between the two types of engine when each is properly installed. This could have been true several years ago, but the results of research were available only recently.

The largest liquid-cooled European-type engines now used by Germany and England develop about 1,200 horsepower, and this year we shall have similar engines in quantity production here. Two new types of American air-cooled engine are already developed and in production in the 2,000-horsepower size. Nowhere else in the world are engines of such power available. The demand for armor, protected gasoline tanks, and heavier armament can safely be predicted to make the 1,200-horsepower engine inadequate in the near future on account of the increased weight involved. Also, there is always a demand in war for more speed. This country can meet these demands by the devel- (*Concluded on page 180*)



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TECHNICAL PROGRESS IN AVIATION

(*Concluded from page 179*)

opment of a 2,000-horsepower fighter to compete with the 1940 European 1,200-horsepower plane. We have the engines and the knowledge of how to install them for high speed.

Production for war is not like production for domestic consumption. The businessman trained in commerce may insist on "freezing" a design and going into production for three years on the same article in order to recover his investment in engineering costs. In war, technical progress on the part of the enemy can make such a three-year program disastrous.

We now have an interesting situation — that of a very large production program for 1,200-horsepower fighter airplanes based on European liquid-cooled engines getting well under way at about the time our own engineers present us with two 2,000-horsepower engines and our scientists show us how to streamline them in an airplane installation to secure extremely high speed. The position seems to be that we are using our great productive capacity for an immediate program of producing fighting airplanes that are the equal of anything known in Europe while we have the potential ability to make obsolete all fighter airplanes in the world today, including our own. This position has come about by recent technical progress in engines and fuels, combined with new knowledge of the aerodynamics of air flow. When to take advantage of the recent technical progress is a delicate question involving a balance between strategic and tactical considerations. It is the old dilemma of quantity now versus quality later and can be decided wisely only when we know whether it really is later than we think.

FROM LOGS TO RICHES

(*Continued from page 163*)

The I.P., as it is universally known, was one of the early pioneers in Canada for pulpwood. Its first Canadian subsidiary was the St. Maurice Lumber Company, now the Canadian International Paper Company, whose mill at Three Rivers used the timber from crown lands in the St. Maurice valley leased from the Quebec government. There is nothing small about the newsprint mill which the Canadian International Paper Company built in 1926 at Gatineau, Quebec, a few miles from Ottawa. It has five paper machines, of which four are 271½ inches wide on the wire — the biggest ever built up to that time. Furthermore, it was to be an *all-electric* mill, from steam plant to shipping room, a project which involved the development of three power sites on the Gatineau River and the impounding of water at Lake Baskatong in one of the largest reservoirs built up to then. So big in fact are the "ponds" above these power dams that a fleet of steam and Diesel-powered tugs is required to tow the huge booms of logs consumed in the mills. The next step was to build a four-machine newsprint paper mill at Dalhousie, New Brunswick. Except for a 6,000-kilowatt turbogenerator, the power for this mill is brought in at 132,000 volts. The mill is on tidewater, and fresh water was obtained by damming the Charlo River, about nine miles away, and laying a 24-inch wood-stave pipe. The machines at this mill have been improved until they have been operated at over 1,400 feet a minute and have the exceptionally high rating of 1,560 pounds of paper per inch of usable (trimmed) width per twenty-four hours.

Comparisons are always interesting. The daily capacity of Canadian International's three newsprint mills is 2,350 tons (723,800 tons a year), whereas the annual capacity of the twenty-eight newsprint machines owned by the Consolidated Paper Corporation, Ltd., is 614,500 tons and that of the six operating newsprint mills of the Abitibi Power and Paper Company, Ltd., of Ontario is approximately 600,000 tons. The American founder and first president of the Abitibi Company was F. H. Anson, and the first plant was a groundwood mill built at Iroquois Falls in 1914. Power was available *in situ*, and the first grinders were direct connected to water wheels. (The only newsprint machine I have seen driven by a water wheel was in the Belgo mill at Shawinigan Falls, Quebec.) The Iroquois Falls mill was one of the first constructed of reinforced concrete, a godsend to the population who took refuge

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there during a disastrous forest fire in 1916. The roof was kept flooded while danger lasted. The Abitibi Company has pioneered considerably in papermaking technique, engineering, and woodland management.

Even the most cursory summary of the Canadian paper industry must mention a few more "firsts" and "onlys": The American-invented vacuum dryer was first used on newsprint machines by Price Brothers and Company in their two big mills at Riverbend and Kenogami, Quebec. The first sulphate (kraft) pulp made on the American continent was done in the original mill of the Brompton Pulp and Paper Company, Ltd., which is now controlled by the St. Lawrence Corporation. First to install a machine more than 300 inches wide (there is still only one wider — a 320-inch monster in England) was the Great Lakes Paper Company, Ltd., at Fort William. The only newsprint mill on the Atlantic Coast that can ship paper the year round by water is that of the Mersey Paper Company, Ltd., at Liverpool, Nova Scotia. Another and very different feature of this Nova Scotian mill is its use of the waste liquor from its sulphite pulp mill for the manufacture of baker's yeast. A chemical achievement of the Howard Smith Paper Mills, Ltd., at Cornwall, Ontario, is the production of vanillin from waste sulphite liquor. The Mersey Company and the two large mills in Newfoundland, which supply British publishers, all have steamers specially designed for carrying newsprint.

THE INSTITUTE GAZETTE

(*Continued from page 169*)

appreciably, for even such small drains of energy as are introduced by ordinary instruments will be reflected as substantial extraneous loads at the full scale of the system being represented. Hence the instruments cannot be permitted to draw off more than minute amounts of power. Such a lean diet naturally leads to anemic and lethargic results unless some dependable means for amplification of this small amount of power is available. This means is found in the negative feedback amplifier, an almost intelligent device which senses external changes and adjusts itself automatically to keep its amplification constant. Because of this feature, the amplifier is a precision instrument. Installed in the analyzer in 1937, a negative-feedback amplifier made it possible to reconcile in the metering the otherwise basic incompatibility of speed, accuracy, and low consumption of power.

At the same time, the main metering equipment of the analyzer was centralized, so that once loading conditions are properly represented, the readings of power flow and voltage at any point in the network are taken on one set of master meters located at the central desk. The master meters speed up the getting of answers to a problem; setting up the problem in the first place is expedited by the complete precise metering equipment at every generating station in the analyzer network. Since the otherwise time-consuming process of establishing given load and voltage conditions is thus shortened, the task of reproducing the desired system (*Concluded on page 182*)

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THE INSTITUTE GAZETTE

(*Concluded from page 181*)

conditions is much lightened. Centralization of the master meters from which answers are read, combined with the presence of the amplifier, so expedites the metering procedure in operation of the analyzer that the speed at which data can be reliably recorded controls primarily the time required for a power-system study.

Both speed and precision are thus provided in the solution of network problems by the analyzer, and both speed and precision are essential in the making of such solutions. Speed makes it feasible to subject the problems to thoroughgoing analyses rather than to approximate surveys based on a multiplicity of assumptions. Precision goes hand in hand with economy of planning and worth of results; for example, where synchronous condensers are used to regulate voltage, one division of the analyzer voltmeter scale may represent $25,000 in condenser capacity. Obviously, thoroughness and exactitude — virtues highly desirable from an engineering or scientific point of view — have equal desirability from the industrial and economic standpoint. Commercial studies made on the analyzer have served to demonstrate many times this combination of qualities in the features possessed by the Technology machine.

IN THE LILLIPUT OF MATTER

(*Concluded from page 160*)

already proved of great importance in the problem of drilling muds for oil wells, in certain phases of ceramics, and in the discovery of Alsifilm, a possible domestic substitute for mica. The use of very dilute clay suspensions in the study of liquid flow is another consequence of this work. Investigation of the alignment of the flaky, colloidally sized particles in correlation with the direction of flow of a liquid or of force provided by electric fields — the alignment being made visible by the use of polarized light — is about to open up an entirely new field of scientific activity comparable with the photoelasticity of solids, and as interesting to the chemical and civil engineer as to the physicist (Fig. 4).

The study, using high-speed motion pictures, of how drops form if a liquid is allowed to flow from a tip culminated in the development of a new method to determine boundary tensions. The pendant drop method, which was first presented in 1938, is based on silhouette photographs taken of drops, and from their dimensions surface tension is easily evaluated. This is the only static method which permits, without interference with the surface, study of changes of surface tension with time (Fig. 5). Notable contributions also have been made in the field of natural and synthetic rubber and plastics, and the work is now also extending to cover fundamental problems in the paper and paint and varnish industries, the textile industry, and the reclamation of rubber. All this development is a result of our firm conviction not only that colloidal dimensions may not be neglected but also that their influence on many varied properties of matter must be subjected to systematic study.

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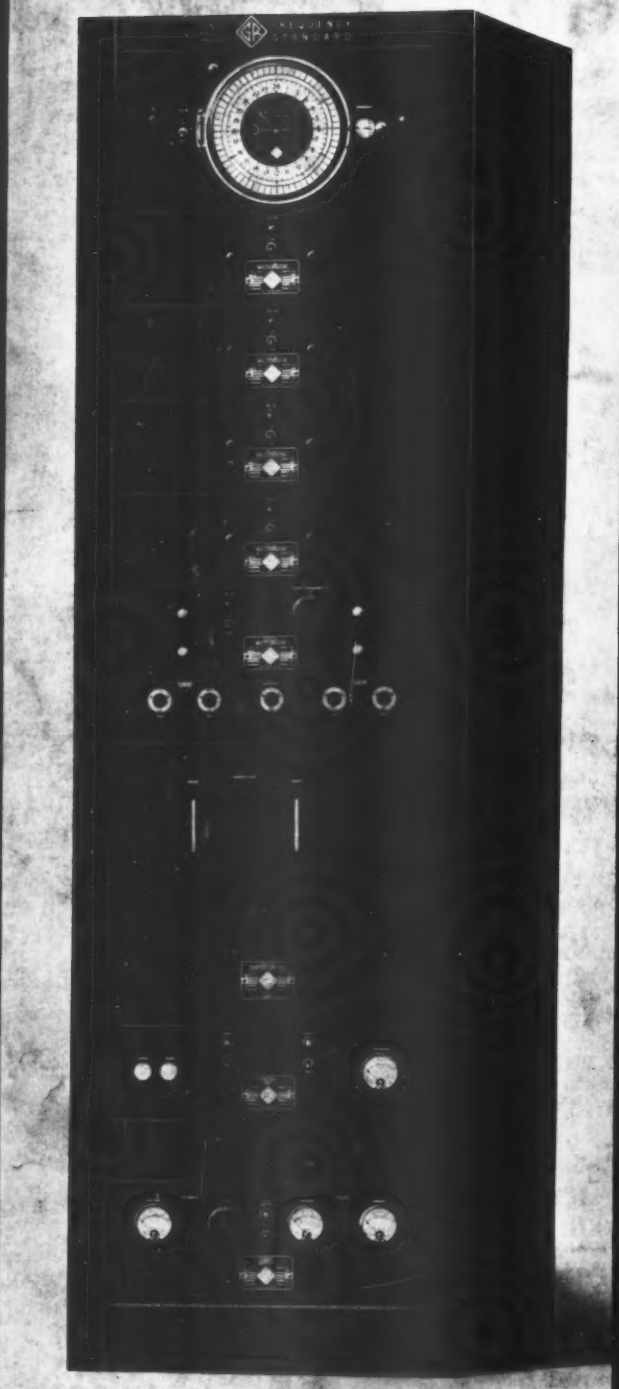

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